HOUSE OF LORDS SESSION 1999–2000

SELECT COMMITTEE ON
SCIENCE AND TECHNOLOGY

NON-FOOD CROPS

EVIDENCE

Ordered to be printed 25 November 1999

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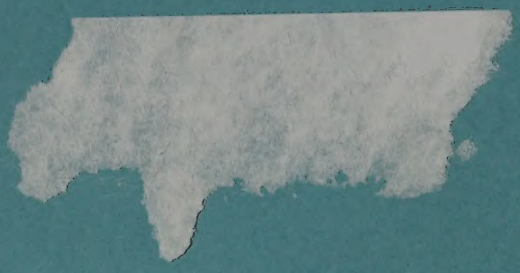
HL Paper 5–I



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NON-FOOD CROPS

CALL FOR EVIDENCE

issued in February 1999

The Science and Technology Committee of the House of Lords has appointed Sub-Committee I, chaired by Baroness Hogg, to conduct an inquiry into Non-Food Crops (i.e. industrial and energy crops). The Committee will take evidence in writing and in person, and produce a report to the House, with recommendations addressed to the Government, later in the year. We invite written submissions on the following questions:

1. What is the potential for the development of non-food crops in the UK? Which crops, if any, are likely to prove significant in terms of economic activity or land use?

2. What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, e.g. by genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability be overcome?

3. What are the environmental and ecological implications of the development of non-food crops? How far can Life Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?

4. Are there regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?

5. In the light of the above, (a) are the current UK and EU subsidies for non-food crops, and the proposals under Agenda 2000, appropriate; (b) are the local, national and EU regulatory regimes appropriate; and (c) is the level and direction of UK and EU public funding for research and development appropriate?

Our inquiry will embrace non-food uses for conventional crops, as well as novel crops. It will be confined to plants, and will not embrace animal products. The inquiry will include fast-growing biomass crops (such as willow), but not forestry or peat. It will include crops for medicinal use, but not tobacco.

We take as our starting-point *Alternatives in Agriculture*, Parliamentary Office of Science and Technology (POST), 1995, and the POST Note *Non-food crops* to be published at the end of February. These can be obtained from POST, 0171-219 2840, fax 2849.

In the area of bioenergy, our inquiry is intended to complement the current work of the House of Lords European Communities Committee (Sub-Committee B) on renewable energy in the EU, and that of the Royal Commission on Environmental Pollution on energy and the environment, by examining energy crops in the wider agricultural context.

MINUTES OF EVIDENCE

TAKEN BEFORE THE SCIENCE AND TECHNOLOGY COMMITTEE (SUB-COMMITTEE I)

TUESDAY 9 MARCH 1999

Present:

Birdwood, L.
Carnegy of Lour, B.
Hogg, B.
(Chairman)
Perry of Walton, L.
Porter of Luddenham, L.
Rea, L.
Soulsby of Swaffham Prior, L.
Walton of Detchant, L.

Examination of Witnesses

MR HENRY BROWN, Head of New Crops and Sugar Division, DR DONAL MURPHY-BOKERN, Head of Unit A (Arable Crops, Crops for Industrial Uses and Pesticides), Chief Scientist's Group, and MR MELVYN ASKEW, Head of Alternative Crops and Biotechnology Group, Central Science Laboratory, Ministry of Agriculture, Fisheries and Food, called in and examined.

PROFESSOR CECIL MCMURRAY, Chief Scientific Officer, Department of Agriculture, Northern Ireland, called in and examined.

MR IAN ANDERSON, Head of Crops, Scottish Office Agriculture Environment and Fisheries Department, called in and examined.

Chairman

1. Gentlemen, welcome to the committee. Mr Brown, perhaps you would begin by introducing yourself and your colleagues. Following that, and before starting our discussion, perhaps you would say anything that you want to say by way of introduction in response to our call for evidence at rather short notice, for which I apologise.

(*Mr Brown*) My Lord Chairman, I am Henry Brown, Head of the New Crops and Sugar Division of the Ministry of Agriculture in London. My division includes the Alternative Crops Unit within the Ministry that is principally concerned with the question of non-food crops. I have with me two colleagues from MAFF. On my immediate right is Mr Melvyn Askew, Head of the Alternative Crops and Biotechnology Group at our Central Science Laboratory in York. We work very closely with the CSL on questions to do with alternative crops. On my immediate left is Dr Donal Murphy-Bokern, Head of the Arable Crops and Crops for Industrial Uses and Pesticides Unit in our Chief Scientist's Group. He is here because one of the things that we do is support R&D. That is managed jointly between the administrators in my unit and the scientists. On my extreme left is Mr Ian Anderson, Head of the Crops, Plant Health and Agricultural Pollution Division of the Scottish Office Agriculture Environment and Fisheries Department. On my extreme right is Professor Cecil McMurray, Chief Scientific Officer of the Department of Agriculture in Northern Ireland.

2. I thank all of you for coming and providing such an expert team in scientific and geographical terms. Before we proceed any further, under the rules that govern the proceedings of these committees it is important that all members make any relevant declaration of interest. Each member shall do so as he or she first speaks. My main interest in this matter is that I am chairman of London Economics which is a consultancy that has clients in both the pharmaceuticals and energy sectors. Mr Brown, perhaps you and your colleagues would like to begin by commenting on the subject-matter of the inquiry and the call for evidence on this topic.

(*Mr Brown*) Perhaps I should explain briefly how the ministry fits into this subject. We see the work in this area as responding to three of the ministry's objectives. The ministry has 10 published objectives, of which three are relevant to non-food crops. First, it has the objective of sustaining and enhancing the rural environment. It also has the objective of seeking to secure an economically rational common agricultural policy. It also has the objective of enhancing economic opportunity and social development in rural communities. We view this activity as dealing with those three objectives. Our first real policy role is to try to achieve the correct common agricultural policy environment so as to encourage, or at least not discourage, interest in non-food crops. We have the problem that the CAP is a rather conservative mechanism which supports the things that it has traditionally supported. Interest in non-food crops tended to arise after the main lines of the CAP had been set. Therefore, in general these crops get secondary treatment. It is clear that farmers will not begin to think about them unless they have support similar to that given to the traditional activities. Farmers will not risk losing money by switching to something unfamiliar that is not supported. Within the different sectors in the past year or so we have been giving particular priority to the development of energy crops. We see them as an important potential contributor to broader government policy objectives, initially with the commitment that the United Kingdom made at the time of the Kyoto Climate Change Conference to cut

Chairman *contd.*]

back greenhouse gas emissions. Secondly, the Government are considering a target for renewable electricity generation. In both cases energy crops could make a substantial contribution to those broader government policy targets. Another part of our remit is to try to encourage interest in the private sector. This is not an activity that the Government can do for themselves. The problem is that as these crops are relatively new there is not a developed market for them. There are no standards, trade channels and not much technical awareness. Part of our role is to disseminate information about these crops by means of a database, website and the publication of research reports. We have had stands at agricultural shows and arranged events to bring industrial users and researchers together to look at it. We have encouraged the Alternative Crops Technology Interaction Network (ACTIN) which brings together the research and industrial communities. Finally, we support research and development. MAFF is one of the sponsors of a joint industry/government LINK programme for research into industrial materials. My unit has an annual budget of £1.1 million for R&D in the area of alternative crops. We have supported projects on issues such as miscanthus fibres, the development of printing inks from woad and the development of short rotation coppice and miscanthus as energy crops. Over and above that activity, MAFF is currently in discussion with the University of York which is interested in setting up a centre for novel agricultural products to integrate work on plant genomics; that is, the connection between a plant's genetic make-up and the products it produces. We hope to be able to give it a substantial contribution to the cost of setting up that work. In all this we try to concentrate our interest in crops with a significant agricultural impact in terms of hectares; crops where there is a broader driver of interest, such as protection of the environment, and crops with a reasonable prospect of viability in the longer term without subsidy.

(*Professor McMurray*) From the perspective of Northern Ireland, the goals of the department in this area are similar to those of MAFF: to promote competitiveness and thereby enable the agri-industry to maximise its contribution to the Northern Ireland economy for the benefit of all those in the industry; to promote the adoption of environmentally sensitive countryside management and thereby maintain, improve and protect the landscape and habitats of the countryside; and, finally, to help strengthen the economic and social infrastructure of rural areas and thereby sustain viable rural communities. We seek opportunities for non-food crops especially in this area. Specifically, we have sought to do the following: improve the efficiency of production, target relevant markets and have an associated R&D programme; provide for appropriate alternatives against the pressures on conventional agricultural commodities; ensure that the financial frameworks and returns to farmers are competitive against the support available to conventional agriculture, which includes the issues raised by the CAP; and take account of local climatic and environmental conditions prevalent in Northern Ireland, including soils. That means that we are interested in specific crops which are different from those in, say, the south east of England. We also ensure that those crops can be utilised on grassland given the limits that would be imposed if options were restricted to the use of set aside land, bearing in mind the very small amount of such land in Northern Ireland. We also work with other government departments, in particular the economic departments of Northern Ireland. They have responsibility for energy policy. For example, if one is talking about NFFO[1] and the use of short rotation crops, we develop programmes in association with that department and our colleagues on the mainland. We want to ensure effective technology transfer and information in order to stimulate interest and uptake where appropriate. Finally, we have a specific interest in short rotation willow coppice. On agri-forestry, which is slightly out of the framework of what we would normally regard as non-food crops, we are interested in hybrid poplars and flax which is a traditional industry in Northern Ireland but also the potential of this crop for industrial use.

(*Mr Anderson*) The policy objectives of the Scottish Office are similar to those of MAFF and the Department of Agriculture for Northern Ireland in terms of sustaining rural development, the economic importance of the common agricultural policy in relation to this subject and enhancing the economic and social development of rural communities. Like MAFF, we have indulged in quite a bit of research. We have undertaken 29 projects involving non-food crops since 1991. Expenditure in 1998/99 is about £720,000. That is related mainly to plant fibre research, oils for industrial use and starch. So far the energy projects, which is our main concentration at present, under the Scottish renewables obligation have been limited to the use of forestry waste, which I understand is not part of today's inquiry. But there is one interesting development on short rotational coppice. I expect that very soon—within the week—an announcement will be made of a possible project in Scotland that uses quite a large amount of willow. However, that is commercially confidential at the moment.

3. Having given us that very useful perspective on the priorities, perhaps you can step outside that for a moment, hover over the land surface of the United Kingdom and give a brief snapshot of what non-food crops are being grown at this moment and some explanation as to why?

(*Mr Brown*) First, perhaps I may make a point that I should have dealt with in my introduction. The Welsh Office is not represented today, but that department has asked me to point out that it has a small involvement in the subject. It also supports a number of research projects into biomass and other products. To turn to your question as to the crops which are being grown at the moment, there are in effect three classes of crops being grown on some scale in the United Kingdom. The largest in terms of area is oilseeds. They tend to be grown for lubricants, for use in surfactants, as speciality chemicals of various kinds and in pharmaceutical applications.

[1] The Non Fossil Fuel Obligation, a mechanism run by DTI to encourage new sources of energy.

Chairman *contd.*]

Linseed oil is used in paints, floor coverings and pharmaceuticals. Last year about 100,000 ha of linseed were grown in the United Kingdom. Oilseed rape is grown for both food and non-food use. Non-food applications include the production of erucamide which is a slip agent used in plastic film. One cannot get one's supermarket plastic bag open at the checkout if it does not have a slip agent. Oilseed rape is also used in lubricants and industrial oils. Last year there were 28,000 ha of rapeseed grown on set aside land essentially for those non-food applications. The second largest group of crops by area is fibre crops, which is essentially flax and hemp. Last year there were 16,800 ha of flax grown in the United Kingdom. This is a long-standing crop and traditionally has been grown for the production of linen. But most current United Kingdom production goes into newer industrial uses, including paper, automotive interior panels and geo-textiles in the form of matting that is laid down to stabilise embankments at the side of motorways and matters of that kind. There were 2,500 ha of hemp grown in 1998. The fibres from that crop are used for purposes similar to flax. The inner core of the hemp has also been developed as a horse-bedding material. Both flax and hemp can also be used in fibreboards for the construction industry. The third group, which is still in its infancy, is energy crops. Willow and, to some extent, poplar trees are being grown as short rotation coppice. They are harvested over a fairly short period—about three years—and the wood is chipped up to produce material for heat and/or power production. At the moment there are about 500 ha of short rotation coppice and another 300 ha are expected to be planted this year. In addition to these broad groups a number of other crops are grown for particular high value applications, none on a very extensive scale. They include things like borage and evening primrose which are used to produce gamma linolenic acid for inclusion in health products, and crops like camomile used as fragrances. That is the present broad picture. There is a small number of crops grown on a significant scale and a number of others grown in quite small areas.

Lord Porter of Luddenham

4. I have two related interests that perhaps I should declare. I am chairman of the Centre for Photo-molecular Sciences at Imperial College which is concerned with photo-synthesis and so forth. I am also president of the National Energy Foundation with a particular interest in energy crops. Mr Brown, you have given us a very helpful introductory summary of the various crops that have future potential. What do you see as the long-term potential? One gets the impression that at the moment the activity is small compared with what we hope it may be in future. Which of the various range of crops that you have mentioned do you see as having a really big long-term economic potential? In particular, to enhance that potential what technological developments do you believe are necessary to achieve economic viability in these crops?

(*Mr Brown*) You are right that at the moment these crops are being grown on quite a small scale. There is interest in growing them on the part of a number of pioneers but there are problems to be overcome before they can be developed and grown on a more significant scale. We believe that the crops with the greatest potential are energy crops. We have the Kyoto commitment to cut United Kingdom greenhouse gas emissions by 12.5 per cent. We are also considering a target for renewable electricity. Both of these are to be achieved by 2010. It is very interesting to discover that although agriculture is a relatively small sector of the United Kingdom economy it accounts for a large percentage of total United Kingdom greenhouse gas emissions (about 12 per cent). We are considering what agriculture can do to make a contribution to mitigating these emissions given the Kyoto target. We believe that energy crops represent a good potential in this respect. When they are used in substitution for fossil fuels they are virtually carbon neutral. If one burns oil and gas they contribute to carbon dioxide in the atmosphere; if one burns energy crops basically they give out the carbon dioxide which they took in while they were growing. We have been working with the Forestry Commission to support the planting of short rotation coppice particularly in connection with Project ARBRE in Yorkshire which is the first wood-fuelled power station to be set up in this country. We have organised a number of events to get farmers in that region interested in growing that crop. We have sought to get a provision for the support of energy crops into the CAP. The committee will be aware that there are discussions on CAP reform going forward right now in Brussels. Within those we have sought to amend the proposal on rural development so as to provide a framework that gives support to energy crops. Frankly, the establishment of a nationwide programme, which we would like to see developed, will depend on the outcome of the Agenda 2000 reform discussions and the United Kingdom obtaining some domestic resources.

5. Why does agriculture make such a negative contribution to the carbon dioxide problem? In simple, circular terms the amount taken in should equal output. Does that negative contribution arise because of the use of oil in machinery and so on? Why does it not balance?

(*Mr Brown*) There are a number of different greenhouse gases and agriculture contributes in different ways.

6. Perhaps we can simplify matters and talk specifically about carbon dioxide?

(*Mr Brown*) Obviously, to grow crops one must use machinery; one has tractors going up and down fields cultivating, ploughing and harvesting. That requires energy and contributes to the greenhouse effect. But agriculture contributes more to the greenhouse effect through the emission of two other gases: nitrous oxide and methane. The first arises from the use of manures and fertilizers on the land. That nitrogenous material in fields tends to give rise to nitrous oxide emissions to the atmosphere. The rearing of livestock gives rise to methane emissions from those animals. Both nitrous oxide and methane are powerful greenhouse gases. The overall effect of these different

Lord Porter of Luddenham *contd.*]

sources of gases means that agriculture makes a big contribution.

Lord Soulsby of Swaffham Prior

7. First, I have no conflict of interest in this subject. Referring to the comments about greenhouse gas emissions from agriculture, I assume you agree that the most fertile land tends to be used to grow crops or to raise animals. Are the examples that you have given most likely to utilise what may be termed marginal or less fertile land where many of the agricultural problems exist?

(*Mr Brown*) Different kinds of crops will be grown on different kinds of land. For example, some crops such as rapeseed are traditional arable crops. If they are grown at all they will be grown on traditional arable land. To some extent whether or not they are grown will depend on the returns from the market. At the moment, broadly the returns for food uses for oilseed are greater than for non-food uses. Looking to the future, we are particularly interested in energy crops. For the most part these crops are trees, although there is also miscanthus which is a grass. These crops tend to grow best in western parts of the United Kingdom where there is a reasonable amount of rainfall. In that area there is also a potential demand for new sources of energy. The upshot of all this is that energy crops are likely to be needed to be grown principally in areas that are currently grassland and are being used for livestock production. There is a particular interest in Northern Ireland for exactly that reason.

(*Professor McMurray*) Our interest in short rotation coppice began on the wet heavy soils of County Fermanagh. That is a very disadvantaged area where we see short rotation coppice having a specific benefit. Obviously, the crop will grow on better agricultural land but one can still achieve very substantial yields in those heavy wet soils. That was where we established a crop-growing programme but also a programme of crop utilisation to ensure that it is suitable for small rural enterprises. You have heard about the ARBRE project involving many hectares. The farm structure in Northern Ireland is such that one cannot put such a package together but it can certainly be put together using co-operative movements given the small field structures and land types in the west of the Province. In relation specifically to short rotation coppice, we know that the economy of the crop is such that the cost of the production of electricity is reasonably high. Through technological developments we seek to improve that equation. We need to improve yields and reduce growing and generation costs. We must also consider how that cost compares with that of other energy sources and the value placed on environmental benefits. We see this as a way of introducing biodiversity into the countryside and bringing about environmental advantages. We see potential for increasing yields. Breeding programmes in Sweden and the United Kingdom are making substantial contributions to that process. That will have a significant effect on the economy of the crop as those programmes progress.

Lord Porter of Luddenham

8. What strategy do you have to increase the efficiency of photo-synthesis, which is essentially what you are saying?

(*Professor McMurray*) The programme of the department (DANI) is not tackling the problem on such a fundamental basis, but we know that with conventional breeding we can make improvements. This is a fairly underdeveloped crop and it has been subject to little improvement. There is a good deal of potential for improving that crop by conventional breeding programmes. For instance, we have already achieved significant improvements in grass production through conventional breeding. Similarly, we expect to achieve improvements in short rotation coppice.

9. Presumably, when you say "conventional" you are excluding genetic engineering?

(*Professor McMurray*) That is a potential for the future. We see future opportunities if that is permitted, for example to improve disease resistance and bring other benefits to crops like short rotation coppice.

(*Mr Brown*) Genetic modification is obviously a relatively new technology which has the potential to do things which we are quite slow in doing with traditional breeding methods. Essentially, these crops are ones that have not had the decades of improvement that have been achieved with everyday crops. There is great potential to improve them through traditional or more modern means.

Chairman

10. I respect your aspiration to increase the efficiency of production, but is it credible that these energy crops can compete without environmentally-driven subsidies with other sources of energy at current oil prices?

(*Mr Brown*) We are in a situation where world oil prices are particularly low. Energy crops are a new technology. These crops are expensive to produce and at the moment certainly would not be competitive without support. The experience of the Department of Trade and Industry, which has had a programme running for some years to encourage the development of new and renewable sources of energy, is that energy crops are starting very much from the same position that other new sources were in a few years ago. The experience is that with economies of scale and technological developments it is possible to bring relatively new sources of energy virtually to the point of competitiveness without subsidy over a period. That may be a 10-year period; it may be more or less. That experience of other energy technologies gives us encouragement that something similar can be done in the field of energy crops. The crops themselves are clearly capable of improvement in productivity of the kind that we have discussed. We have already seen that yields have gone up over the past few years by about 50 per cent. We need to continue that process and reduce the costs.

Lord Porter of Luddenham

11. To what crop are you referring now?

(*Mr Brown*) I am referring to yields from short rotation coppice in terms of tonnes per hectare of wood chip. They have already gone up from about 12 to 18 oven-dried tonnes per hectare per annum. Obviously, we need to continue our efforts to improve that yield. If we do these crops will begin to look viable, but I cannot pretend that that will happen in the next year or two.

Chairman

12. Using that yardstick, what yield per hectare has to be achieved in order for those crops to be competitive with other energy sources given today's oil prices?

(*Mr Brown*) I am not sure that I can be too specific on that matter.

(*Professor McMurray*) The energy cost would have to fall to about 2p to 3p per kilowatt hour. We believe that the cost that the crop can achieve at present is 4p to 5p per kilowatt hour. Therefore, a 50 per cent reduction could make it competitive with other sources.

Baroness Carnegy of Lour: I am not a member of the committee but I was a member of the previous committee. I do not have an interest either in this or in farming, although I had a sizeable interest in farming in the past. It is somewhat esoteric to talk only about the productivity of coppice wood. As to profitability, in large measure it must depend on where the manufacturing process takes place relative to the area where the coppice wood is grown. For example, I believe I am right in saying that the timber which supplies a factory producing high-grade paper near St Andrews in Fife, some of which originates in this country, must first go to Scandinavia for processing and then return to Scotland. Obviously, that puts up the price of the final high-grade paper produced in Fife. Is it not much more practical to consider not only the ability of people to grow high yield crops but the development of manufacturing processes near where the growing takes place?

Chairman

13. Before the witnesses respond, I should point out that we are not looking at timber crops in this inquiry. Perhaps the witnesses could focus their response on the kinds of energy crops to which reference has been made.

(*Mr Brown*) Baroness Carnegy is absolutely right. One needs to look at the whole chain. It is no use encouraging crops if there is not an outlet for them. Equally, it is no use encouraging outlets unless there is a source of crops available. This is the problem that one encounters all the time in the non-food crops field. It is said that people would grow them if there were users and people would use them if there were growers. One needs to take a holistic approach to this matter. It is very interesting that in the energy field there are big changes in train in the market. I do not pretend to be an expert in that because this is the responsibility of the DTI. However, we are tending to move away from the tradition of establishing a small number of very large power stations in this country. If one is on a train one tends to see an enormous number of cooling chimneys as one passes these power stations. The electricity from those stations is then taken to where it is used by means of very expensive grid transmission systems. We are tending to move to a more decentralised situation where the energy generation takes place in much smaller units in more local places where the energy is required. This has the benefit that one then does not need power cables striding across the countryside. As I understand it, it is a more economic way to proceed. The result is that the price of the electricity that is viable is higher if it is generated near the point of consumption than the price of electricity in the present market which is based on these very centralised units. There is a trend towards decentralisation. In the case of energy crops, it is very important to ensure that they are stimulated in conjunction with the user. There could be satellite arrangements, as it were. A plant would be established in a particular locality and one would want the crops to be grown in a narrow radius of that locality to avoid precisely the transportation costs that Baroness Carnegy indicated.

(*Professor McMurray*) That is exactly the strategy that we are adopting in Northern Ireland. We take a holistic approach to the matter. We envisage small regional power plants. That flows from our programme of utilisation. We realised early on that there was no point in growing these crops if we could not use them. We installed an experimental combined heat and power system at one of our agricultural colleges. That produces electricity and the waste heat from the system is used to pre-heat the water going into the college. That project was built with support from the European Development Fund. We have gone through proof of concept, sorted out specific problems that have arisen and integrated technologies that have been brought together for the first time. We have been able to extend that technology to the commercial sector. A small company called Rural Generation Ltd is now manufacturing and packaging this equipment. It has already established units not only in Northern Ireland but in Nottinghamshire. Given the Non-Fossil Fuel Obligation, an electricity outlet has been provided for that particular development.

Lord Walton of Detchant

14. The only relevant interest I declare is that my son is a farmer in the Scottish borders and is a member of the Scottish NFU Council. A peripheral interest is that I am an occasional neuroscience adviser to a pharmaceutical company. I return to the question of technological innovation and the whole issue of genetic modification. Bearing in mind the report of this Select Committee a few years ago on biotechnology, one assumes that the same principles apply to the genetic modification of non-food crops as those that apply to food crops; in other words, there is a prospect of potential improvement in quality, pesticide resistance, yield and so on. However, presumably the same anxiety expressed by the environmental lobby may arise about the possible transfer of the modified genes of such crops

Lord Walton of Detchant *contd.*]

into the wild environment. Do you believe that such genetic modification is likely to increase the quality of non-food crops for future energy use?

(*Mr Brown*) There is great potential in the genetic modification of non-food crops as in food crops. As a matter of practical reality I believe that some plants are easier to modify than others. One of the crops in the non-food area that we are considering is rapeseed. That crop is currently being modified, not particularly for the purposes of energy production. It would be one of the first crops to be grown in the United Kingdom if GM crops were permitted here. I do not know how easy it is to modify willow trees, which is essentially what we are talking about. I am not aware that it is impossible to do it, but I do not believe that that is being done at the moment. If it were done there could be the same environmental anxieties that particular interests have expressed about the growing of food crops. It is clear that the Government would want to take a very precautionary approach to this matter. If there were any suggestion of an environmental problem arising from such activity one can be sure that the Government would approach this very cautiously.

15. An article in the *New Scientist* last week strongly suggested that a particular strain of oilseed rape which was being cultivated in certain parts of the world carried much greater threats to the environment than genetic modification. Another report of this Select Committee (Towards Zero Emissions for Road Transport) examined very carefully the role played by biodiesel as a potential fuel for road transport. The evidence suggests, as the European Communities Select Committee concluded almost nine years ago, that as yet these fuels, or energy derived from crops, were by no means competitive financially with other hydrocarbon-derived fuels. Do you think that the situation is improving?

(*Mr Brown*) I am sure that the situation is improving generally. Some crops have had more chance to improve their position than others. Rapeseed used in biodiesel is one of those that has been grown and used on quite a large scale for some years. There is a body of experience on this issue. As I understand it, the factories that produce biodiesel tend to require subsidy from the governments that establish them. Obviously, the crop has support under the Common Agricultural Policy. When the fuel is produced it will not sell unless it is exempted from fuel duties. For example, in Germany there is no fuel duty on biodiesel, and that is worth something like one third of the retail price of the product. The experience is that biodiesel requires quite a large and apparently continuing level of support to make it viable. We try to make comparisons between different crops. When we look at the saving to greenhouse gas emissions from growing solid biomass of the kind that we are keen on—willow and, potentially, miscanthus—the ratio between the energy put in to produce them and the energy that we get out is very much greater for willow (20:1) than for rapeseed (2.5:1). The benefit and potential saving in carbon dioxide emissions from the use of these crops appears to be much greater for solid bio-fuels than for liquid ones.

16. Referring to Q4 on the paper, it follows that compared with other European Union Member States—you referred to Germany—the United Kingdom is at a disadvantage. Does that apply to all of the non-food crops or only one?

(*Mr Brown*) I do not believe that as a whole the United Kingdom is in a disadvantageous position with regard to non-food crops. Each Member State has different climatic and agronomic conditions. Some things will grow better in one country than in another. The United Kingdom is quite a good place in which to grow rapeseed, so we are not at a disadvantage climatically. When one comes to short rotation crops, in some parts of the United Kingdom the climate is quite favourable. The same applies to parts of Scandinavia. The Swedes have done quite a lot of work on this crop.

Lord Perry of Walton

17. You began by saying that one of the big objectives for which you were aiming was an improvement in the rural environment. What benefits do you believe the production of these non-food crops will have for the rural environment?

(*Mr Brown*) Frankly, there are potential pluses and minuses from any new activity. It would be perhaps unrealistic to claim that all the factors were on one side of the equation rather than the other. Some of the crops that we are interested in growing are seen as having relatively low inputs in terms of the chemicals required to produce them: fertilizer or pesticides. That is the case for flax, linseed and short rotation coppice. Energy crops are being developed for the particular environmental purpose of saving carbon dioxide emissions, so I shall not go into that any further. That has already been discussed. Tree crops are likely to have added benefits in terms of biodiversity. They provide cover for birds and small mammals and insects. Once established they can prevent soil erosion. They can also have a beneficial use in what is called bio-remediation; namely, the treatment of effluents which are otherwise difficult to deal with and the removal of pollutants like phosphates, nitrates, heavy metals or other organic compounds. One needs to consider carefully what one plans to grow and where and check that the advantages outweigh any disadvantages.

18. You mentioned in passing the fact that energy crops may reduce the number of pylons that stretch across the land. Is that not also an environmental benefit?

(*Mr Brown*) That is an interesting additional benefit which I had not thought of before.

19. How might a change in the environmental agenda affect the competitiveness of non-food crops?

(*Mr Brown*) There is a change in the environmental agenda. There is an awareness of environmental issues and concern about sustainability in a way that has not happened in the past. This is likely to have the effect of encouraging industrial users to seek out renewable raw materials of one kind or another. For example, car and vehicle manufacturers are anxious to use lighter and more recyclable materials. Flax and hemp could be used for interior moulded panels in place of fibreglass and products produced from

Lord Perry of Walton *contd.*]

petroleum. Those products are lighter and easier to recycle. Paint and detergent companies are anxious to move away from petroleum-based products. Utility companies have expressed an interest in selling green electricity from renewable sources. These are all moves that I view as a response to customer preference. There is a certain amount of driving force from the consumer end, and I am sure that there is scope to build on those pressures. The more the subject of sustainability is understood by the public the more they are likely to demand that the things they buy should be made in sustainable ways. That can have only a beneficial effect in the areas about which we are speaking.

Lord Birdwood

20. You said that not all the consequences were positive. Can you pinpoint any factors that are noticeably negative?

(*Mr Brown*) We are talking about crops and changes to agricultural practices, if we produce new ones. We are conscious about the fact that there have been concerns about the intensification of agriculture in the past few years. I do not believe that the crops we are talking about are particularly susceptible to criticism from that point of view, but it is something that we need to bear in mind all the time. For example, rapeseed is seen as an intensive agricultural crop which is grown in rotation with other cereals, sugar beet and other crops of that kind. If we are pressing for greater production of such crops we must consider whether there may be an environmental drawback. If we set up a programme to encourage energy crops—short rotation coppice—we believe that there should be a mechanism to monitor the environmental effects, for example the impact on the water table, the leaching of nutrients through the soil and the impact on biodiversity in terms of animals and plants. I hope that if we have a programme that involves growing this crop on a significant scale the effects will be found to be as benign as we suspect they are. But this is not an area in which we can take things for granted.

Lord Walton of Detchant

21. Is it not the case that there is an increased incidence of asthma and other allergic disorders in communities close to where oilseed rape is grown?

(*Mr Brown*) There is quite a lot of concern about the health effects of growing oilseed rape. A couple of years ago the Ministry asked the Institute for Environmental Health to do a survey into that question. It reviewed the then state of knowledge and concluded that there was no direct evidence of a link between oilseed rape and people's asthmatic and allergic reactions. The evidence appeared to be that people who were atopic—that is, susceptible to these kinds of allergies—were the ones who reported the conditions in areas where oilseed rape was grown, but it was not possible to establish a link between the growing of that crops and the reported conditions.

Lord Rea

22. I do not have any relevant interests to declare. How does the smoke effluent from burning short rotation coppice compare in terms of the output of sulphur dioxide and nitrous oxide with the burning of fossil fuels and the production of acid rain?

(*Mr Brown*) As I understand it, this is a very clean fuel. The crop is grown, chipped up and dried before it is used. I know exactly Lord Rea's concern; namely, there may be smokey bonfires with a lot of emissions to the atmosphere. From what I have seen of its present utilisation, what comes out of the stack is more or less invisible. It is not high in sulphur dioxide or nitrogen oxides. There does not appear to be a problem arising from emissions from the stack.

Lord Birdwood

23. Still on the subject of baleful rather than benign consequences, right at the beginning you touched on the accumulation of databases. High in any national priority must be some kind of predictive capability rather than letting things happen and seeing what the consequences are. Can you enlarge on the role of MAFF in knowledge management in non-food crops, the accumulation of data warehouses in this area and access to data by parties who may be interested in pursuing this matter?

(*Mr Brown*) A number of mechanisms have been developed here. When the Alternative Crops Unit was set up in MAFF five years ago we drew up a database of crops and people interested in using them. Since then there have been developments on this front. The Alternative Crops Technology Interaction Network, who I believe the committee is to see in a few weeks, has developed its own database of people interested in using these crops. If one has the password and looks at its website, this is an Internet database which is quite impressive. We have not tried to duplicate it but give it as much encouragement as possible to make it the United Kingdom point of reference for people who are interested in these crops. In another area there is a European Union initiative called IENICA. Melvyn Askew is the co-ordinator for IENICA, so perhaps I can ask him to explain what that body is doing in the field.

Lord Perry of Walton: I should have said that I do not have any interest to declare.

Lord Porter of Luddenham

24. Before we leave the question of environmental impact, I should like to hear from Mr Brown about sugar beet as a possible non-food or energy crop since he heads the New Crops and Sugar Division.

(*Mr Brown*) I have not said anything about sugar as a non-food crop. We are not doing any particular work on sugar at the moment. Sugar is used on quite a substantial scale in some parts of the world for the production of alcohol. For example, Brazil has had a big alcohol programme which, as I understand it, is not going very well. There is also some interest in sugar beet as a non-food crop in Europe, in particular Holland. We do not view it as a priority.

Chairman

25. Before we leave environmental issues, I wonder whether Mr Anderson or Professor McMurray would like to say anything about the appearance of these crops in wilderness areas. An article in the *Financial Times* refers to the lyrical picture of willows to be found at the bottom of people's gardens. They may not look quite so lyrical once the tops have been cut off to be used for energy.

(*Professor McMurray*) The crop is not harvested in its totality. We run a three-year cutting cycle so that the planting and harvesting of the crop is such that there is always two-thirds on the ground at any one time. One is shaving off only one third of the crop. Once one has it in production one wants to continue the cycle. That prevents the complete denudation of the landscape, as it were. We are trying to develop a patchwork of small farms so there are not massive areas of short rotation coppice but biodiversity within the landscape. But you are right that if there were vast areas of coppice it would change the character and would not be in keeping with the diversity of landscape of Northern Ireland.

(*Mr Anderson*) This is an issue that must be considered, and there is a precedent in the form of the development of forestry plantations.

(*Professor McMurray*) I should add that, instead of using single varieties, because of the diseases to which the crop is subject we use mixed varieties which in themselves provide diversity in planting.

Lord Soulsby of Swaffham Prior

26. In the case of willow, do you envisage a monoculture crop, or is it possible to mix it with some other non-food crop or food crop? There was a time when one mixed grassland grazing with forestry. Is it possible to do that with some of the non-food crops that we are considering here?

(*Professor McMurray*) We see a patchwork developing so that small farms do not devote all their activities to short rotation coppice but still pursue traditional activities. We see a matrix of various crops being produced but it would be mostly grassland as distinct from short rotation coppice.

27. Would that be better environmentally than the monoculture-type approach?

(*Professor McMurray*) We see that as having a benefit in terms of biodiversity within the landscape. We have been looking at that aspect in terms of nature conservation. Organisations in this area have been looking at the biodiversity of these plantations and what kind of wildlife can be encouraged. This is a very positive outcome.

Lord Soulsby of Swaffham Prior: It seems to me that you could take a very positive attitude to the environment and provide biodiversity without affecting the cropping systems.

Lord Walton of Detchant

28. You hinted in your opening statement that the Common Agricultural Policy had been rather slow to recognise the importance of non-food crops. Can we assume that these crops are not yet on a level playing field under the CAP? If so, what support is available for the production of these crops?

(*Mr Brown*) There are different things for different crops. At the moment it is possible to grow non-food crops on set aside land and receive the set aside payment for that land. That is tantamount to getting aid for growing those crops. A finite list of these crops is published in a European Commission regulation. If one is on it one can grow them and get the set aside payment; if not, one cannot get that assistance. There is a separate small regime for flax and hemp which provides aid per hectare for these crops. The European Union production of these crops has gone up quite sharply in recent years in response to interest from industrial users. On an European Union scale flax increased from 52,000 ha to 166,000 ha between 1993 and 1998. Hemp went up from 7,000 ha to 42,000 ha in the same period. Some people would regard it as rather a good thing that there is increasing interest in non-food crops, but the Commission in Brussels does not see it that way. It has tended to regard this as an abuse of the original purpose of the flax and hemp regime which is to support the production of fibre for traditional woven textiles. Instead of welcoming this new interest it has sought to clamp down on the regime in order to stop it. It has imposed compulsory contracts between the farmer and processor, minimum yields for flax and stringent limits on the drug content of hemp. Reform of this regime is due in 1999. I should not be at all surprised if the Commission proposed a further tightening up of the regime. In the field of energy, these crops can be grown on set aside in the way that I described at the start, but there is no European Union support for their establishment. The establishment is the most expensive problem with these crops at the moment. The United Kingdom has been paying a national aid for their establishment on a pilot basis, particularly in Yorkshire. That is why we have been pressing in Brussels in the context of the Agenda 2000 discussions to have aid for establishment included in the rural development regulation. There is a little bit of a patchwork of provision at the moment as to those crops that can be grown and the support that is available. I do not believe that they are on the same footing as the traditional crops.

29. Can you tell us what appears to be the motive underlying the attitude of the European Commission which at first sight appears to be somewhat illogical on this issue?

(*Mr Brown*) I think I understand where the Commission is coming from. It is responsible for managing the CAP and ensuring financial propriety and that the money is spent on the intended objectives. The Commission is concerned that regimes set up for one purpose may be used for another. It sees that as misguided.

Chairman

30. That is an unusual, even commendable, approach on the part of the Commission, is it not?

(*Mr Brown*) Absolutely. The United Kingdom Government are one of the strongest advocates in Brussels of this rather narrowly focused concern

Chairman *contd.*]

about the proprieties. This happens to be an area where we are faced with the consequences of that kind of approach.

Baroness Carnegy of Lour

31. The previous report on this subject in 1990 in which I took part looked at various non-food crops, many of which we have discussed, and concluded that the problem of making them profitable was closely related to the world price of cereals at that time. Figures were quoted. The report gave the level to which world price would have to drop for these crops to be viable. Can the witnesses say what has happened to the world price of cereals since then, with or without subsidy as far as this country is concerned? That cannot be disregarded by the committee as an element in what makes these crops viable for farmers at the moment. It would be helpful if the committee was made aware of what was happening on the ground from the point of view of farmers.

(*Mr Brown*) I do not recall precisely where cereal prices were 10 years ago when the previous report of this committee was drafted. But cereals are at relatively low prices at the moment. The purpose of the Agenda 2000 reforms generally is to enable European Union producers to produce at world prices. That is already possible for rapeseed because that crop does not have any price support. If Agenda 2000 goes through as the Commission proposes that will be virtually the situation for European Union cereal producers as well. That raises a question as to the relative profitability of these crops compared with cereals. The present problem is that these would not be as profitable. If a farmer had a choice as to whether or not to grow these crops he would probably decide against it. In the past few years we have had arrangements under which farmers have had to set aside some of their land. That has itself provided a powerful incentive for the development of non-food crops because they are one of the few things that can be done on set aside land. The Agenda 2000 proposals by the Commission are to fix the set aside rate at zero and basically suspend obligatory set aside. Although voluntary set aside would still be possible so that farmers could grow these crops and pick up the set aside payment it would not be obligatory. That takes us back to my earlier point. If the market price for food crops is higher than for non-food use the likelihood is that farmers will put their efforts into the production of food. Given the whole background, we have tried to think in terms of targeted aid under the rural development chapter, which is completely separate from commodity support, for the encouragement of these energy crops.

Lord Soulsby of Swaffham Prior

32. You have given us an account of the European Union regulations which to my mind constrain production in the United Kingdom. Perhaps I may jump to Q12. Do the same constraints apply all over the European Union? The crops that you listed are well known in this country, but are there others in the European Union where these regulations would not apply and they would be given favourable treatment compared with what one may perceive to be the unfavourable treatment of some of our producers?

(*Mr Brown*) As a general rule, the support that can be given is either European Union or national support. Obviously, there are some crops that we do not produce in the United Kingdom, for example olives, which receive support under the CAP. One may say it is unfair that we do not receive any aid for olives, but that is not a relevant crop given our climatic conditions. I do not believe that there is a problem with European Union support, even though some crops grow in some circumstances and not in others. One example is starch from potatoes. That receives aid under the CAP. However, we do not have any access to that aid because we were not producers of potato starch when the arrangement was set up. We never got access to it. But, generally speaking, I do not believe that the CAP is a problem; nor in most respects is national aid a problem. If Member States want to introduce national aid to a particular sector they must get it cleared in Brussels. Obviously, the Commission looks at questions to do with the distortion of competition and is quite alive to problems of that kind. As a rule, our experience in this area is that national support has not caused a problem either.

33. We are dealing with regulation here. Mention has been made of genetic modification. I presume that because of the European regulations on genetic modification relating to food-producing plants and animals the same would apply to non-food crops, or would they? Is there different thinking on that? I am aware that environmental issues arise here, but are there any other matters of which we should be aware?

(*Mr Brown*) Essentially, the regime for the release of GMOs for commercial growing requires a test of whether they are likely to cause harm to human health or the environment. If one were talking about non-food crops one would hope that as a general rule there would not be a problem on the human health front because people would not be eating them. Nevertheless, the same environmental question marks would be applicable as for food crops. Supposing that someone wanted to grow genetically modified non-food crops of some kind, he would be subject to the same tests as those applied to genetically-modified food crops. I do not think that there would be any question of the Government giving them favourable treatment because they would not be used for food.

34. A few years ago this committee concluded that the regulations in both the European Union and in this country constrained trade and industrial development. That applied particularly to genetically-modified organisms used in industry and activities concerned with the export trade. I presume that none of these products are exported at present, or is there an export market for any of the non-food crops that we are talking about?

(*Mr Brown*) In some circumstances there is. To an extent, it depends on the product in question. If one is concerned with energy crops, wood chip is a bulky low-value product which must be used near to the point of production. This question was raised earlier

Lord Soulsby of Swaffham Prior *contd.*]

by Baroness Carnegy. The likelihood of an international trade in wood chip is fairly low. Fibre crops are used particularly in Germany where car manufacturers are more environmentally involved than in this country. The fibre from United Kingdom flax and hemp may be going into car manufacture on the continent. For example, linseed oil is used in other Member States. Rapeseed oil can be used elsewhere. For products of that kind there is such a market. However, for energy crops the market tends to be very localised.

Chairman

35. In the regulatory area there is one aspect on which we have not touched so far. Reference has been made to the need to establish processing plants near to the point where these crops are planted. Issues arise under the planning regime. To what extent is that a constraint in the United Kingdom, and how does it compare with elsewhere in the European Union?

(*Mr Brown*) Planning is slightly outside my field of expertise and is really more a matter for the Department of the Environment than for MAFF. There have been examples of planning difficulties. There is a project to set up a biomass power station in mid-Wales. The planning application for that project was refused a few months ago. I understand that the developer concerned hopes to appeal against that decision. Certainly, in that case there was local opposition to the development, not because of the growing of the crop but the siting of the plant. However, Project ARBRE in Yorkshire had no difficulty with planning permission but that may be because it is being built in the shadow of a larger established power station and so it is not seen as a further threat to the local environment. As to whether the planning regime in the United Kingdom is more stringent than on the Continent and that makes for difficulty, I am afraid that I do not have any information. It has not been suggested to me that it is.

36. When this matter was previously considered the Select Committee on the European Communities pointed to a lack of co-ordination between the interest groups on the one hand and different regulatory bodies on the other. Is that still a problem? As a rider to that question, how do you co-ordinate and co-operate in the development and research programme? A number of projects taking place in the United Kingdom have been described by Mr Anderson and yourself. Are those co-ordinated to ensure that there is maximum furtherance of knowledge in the technological field?

(*Mr Brown*) You are right that co-ordination is important. These crops are new. There are potential producers and buyers. There are no commercial channels and there is a need for more know-how and co-ordination. That was one of the reasons why the Alternative Crops Unit was set up in MAFF in 1994 to act as a focus for that co-ordinating effort. We see it as part of our role to encourage interest among others but we do not aim to do it all ourselves in government. We have encouraged other activities that we regard as important co-ordinating functions. I have referred to ACTIN. Another organisation that has been set up is IENICA, which is a European body. Perhaps Melvyn Askew can say a brief word about that.

(*Mr Askew*) IENICA is funded by the European Commission initially for three years to the extent of 412,000 ecu. It involves 14 European countries—all members except Luxembourg. Hungary has just joined at its own expense. The significance of Hungary is that it is an accessing state. Poland is considering whether it will pay to join, but it is certainly playing a part informally. The IENICA project involves three work streams. If you wish I will provide to the Clerk later written information on those matters. The first is the setting up of an assessment of industrial crops in Europe; the potential for them, problems and the opportunities on a state-by-state basis. Currently, I have in about the first eight in draft form. I hope to have the rest fairly quickly. Following that, as part of the contract I shall put together a review of where Europe is going in the field of industrial crops, the opportunities, the problems and so forth. The next issue relates to a very big database on the worldwide web. In the past few months about 4,000 people have accessed that database. Basically, it is a list of plants that can be grown throughout Europe. Some are not British. It describes the plants botanically, their products, their potential markets, if we know—sometimes we do not—and some of the problems that may arise from them. Some of them are no better than pernicious weeds at this moment. The ones that may provide new resins are fairly unadapted. We then link through to another European database which provides all the results of European Union-funded work on non-food crops. Basically, the IENICA database is a one-stop shop. We also link to other networks and individuals, be they researchers or industry. We can go straight into their databases and gain information in that way. As an aside, it is interesting to note that virtually all academics access databases but industry has much less time, interest and enthusiasm. I suspect that industry often does not realise what may be available, perhaps for good reason. The last part of the IENICA database is publicity in the form of news sheets, which I shall leave with the committee, and seminars. The news sheets come out as pan-European documents every three to four months. The content varies according to the topics, for example fibres from Finland and, in the past few weeks, a good deal of French material on replaceable oils. The final part of that third workstream is seminars intended primarily for industry. One was set up in Denmark. That is being patronised at this minute by Crown Prince Joachim to give it more whack, as it were. That is concerned with fibres specifically for industry. People like Mercedes-Benz are speaking at that seminar. If you wish, I can provide a copy of the programme. Later in this year there will be a similar meeting in Nice aimed at personal products: perfumes, essential oils and matters of that kind. Finally, there will be a meeting definitely in the Netherlands, probably at the research centre in Wageningen, on oils for industry and, subject to European Commission agreement, what agriculture can do for oils post-Agenda 2000. Therefore, I believe that we have a fairly extensive

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network which is available at no charge whatever, other than the need to provide the necessary equipment to receive it. We mail data to large numbers of people. The current mailing list is about 1,400. I believe that we have made quite a good start at pulling together the needs, which is perhaps the important aspect for industry, and the potential, which is perhaps the important aspect for the agricultural industry.

(*Mr Brown*) On the important question of co-ordination, since the previous report quite a number of co-ordinating activities have occurred. One matter about which we are concerned is the lack of co-ordination in the policy framework of the Commission in Brussels. The agricultural directorate, DGVI, see its job, quite rightly perhaps, as being to manage the existing CAP efficiently. It has not taken as much interest as we think it could have done in the development of non-food crops. About 18 months ago the energy directorate, DGXVII, produced a White Paper on renewable sources of energy which, among other things, envisaged a tripling of the area of biomass production within the Union. Obviously, that would have major implications for agriculture and agricultural policy, but the implications for the CAP were not really addressed in the White Paper. When DGVI subsequently brought forward its proposals for CAP reform in Agenda 2000 the White Paper on renewable energy was simply ignored. That is one example. Similar examples have arisen over fibres and oilseeds where work in one part of the Commission has not apparently led to any action or sympathy within DGVI. As I have tried to explain on and off throughout this morning, what farmers do is dictated to a large extent by the state of the CAP. If the CAP does not encourage it or discourages it the likelihood of it coming about is remote.

37. Thank you very much for that pointer. I assume that the implication of your remarks is that such a thing could never happen in Whitehall between you and your colleagues. We are beginning to trespass on your time. I know that you will kindly provide us with written evidence, but as you are giving evidence at the very beginning of our inquiry we are open to any suggestion that you may want to make at this stage. Is there anything that you want to say in conclusion?

(*Mr Brown*) All I would say in conclusion is perhaps what I should have said at the start. We very much welcome your committee's inquiry into this subject. We hope that the result of it is to stimulate more interest in the subject at both governmental level in the United Kingdom and Brussels and in industry. I look forward to the report.

Chairman: Thank you very much for coming to give evidence.

TUESDAY 16 MARCH 1999

Present:

Birdwood, L.
Hogg, B.
(Chairman)
Middleton, L.
Porter of Luddenham, L.
Rea, L.
Selborne, E.
Soulsby of Swaffham Prior, L.
Walton of Detchant, L.
Winston, L.

Examination of Witnesses

MR BEN GILL, President, NFU, and Chairman, ACTIN, MRS RACHEL WRIGHT, Alternative Crops Adviser, NFU, MR IAN BARTLE, Chief Executive, ACTIN, DR PHIL TAYLOR, Research Associate, ICI Paints, and MR ANDREW HEBARD, Managing Director, J K King & Sons, Alternative Crops Technology Interaction Network, called in and examined.

Chairman

38. Ladies and gentlemen, thank you very much for coming to give evidence to the Sub-Committee at what I appreciate was relatively short notice, so double thanks for that. Mr Gill, in particular thanks to you because I gather not only are there, as it were, two of you here today, or at least two hats on one head, but you have also kindly agreed to act loosely as chairman of this group giving evidence today, but please feel free to spin questions out. Indeed, I hope all of you will feel free to come in on any question or signify that you would like to add to what has been said. Mr Gill, could I ask you, however, to start by introducing your dual self and the other four present?

(*Mr Gill*) Thank you, Chairman, and thank you for this opportunity to come today. I am the President of the National Farmers Union of England and Wales, a farmer from North Yorkshire, but I am also Chairman of ACTIN. Perhaps I might add a few words about the interrelation of all that in a minute when I have introduced the other members of the panel, if that is agreeable. On my extreme left is Ian Bartle, who is the Chief Executive of ACTIN, the acronym standing for Alternative Crops Technology Interaction Network, which represents the United Kingdom interests in developing crop-derived raw materials as renewable feedstocks for industry and has links into Europe, on which more in a minute. Ian also is the link co-ordinator for competitive industrial materials, non-food crops, and was recently made Vice-President of ERMA—more of that later. I am sorry for the acronyms. On my immediate left is Rachel Wright, who is the Policy Adviser within the NFU on non-food crops. On my right is Dr Phil Taylor, who is a Senior Research Associate with ICI Paints, a member of the board of ACTIN, but within ICI is leading the internal ICI and the European research projects on crop-derived materials for industrial uses, and on my extreme right is Andrew Hebard, who is the Managing Director of Kings of Coggeshall, who has major interests in that remit in supply chain management. Chairman, if I might explain those acronyms and where we are, I was asked by the then President of the NFU, Sir David Naish, some seven years ago to look at the whole subject of non-food crops to see if this was one of these silly ideas or whether there was a reality in it. I spent a lot of time going round the country visiting research establishments. At that particular time I was a Council member of the then research council, the Agriculture and Food Research Council, which then became the Biotechnology and Biological Sciences Research Council (BBSRC). Latterly I was Chairman of the Agricultural Systems Directorate of that Research Council until a year and a half or two years ago, so I had an active involvement in the subject and became aware that there was an absolute wealth of information around the country that was not being properly co-ordinated. We had, on the one hand, coming out of a conference that the DTI organised some five years ago an inability for industry to converse with science, almost to the extent that there were two different languages, and on the other hand, we had no mechanism for co-ordinating the different scientific disciplines, and the whole subject of non-food crops being a totally new arena we needed to bring together the chemist with the biologist, with the engineers, with the mathematical modellers, with the whole gamut of scientific disciplines that were there to effect the maximum output from our industry. I had a chemist approach me from a university in the south, saying, "I have all sorts of ideas about molecules. I think it would work but I cannot find a biologist to talk to." All that and many other aspects, indeed, looking at what were the potential markets and looking at political overtones, led to the establishment of ACTIN, the Alternative Crops Technology Interaction Network, which was a unique body in that it was co-funded fifty-fifty from industrial sponsors, of which Dr Taylor is one, and at that stage by BBSRC. What we have done under Ian's guidance as Chief Executive is establish a unique database, which is interrogable on the Internet, to bring together all these disciplines, which has gone absolutely from strength to strength. In discussions with the European Commission at that stage it became clear that they felt that this needed to be taken a stage further. We have clear strengths in the United Kingdom, which I am sure you will want to come back to. Other Member States had other strengths and it was a waste of resource for us all to be duplicating one another's efforts in this connection. This led to the establishment of IENICA—I am stymied again. Ian?

Chairman *contd.*]

(*Mr Bartle*) Interactive European Network for Industrial Crops and their Applications.

(*Mr Gill*) We have lovely sessions dreaming up these names. Thank you very much. That was funded by a European Commission grant of about 400,000 ecus at the time, and Dr Melvyn Askew, then of ADAS now of the Central Science Laboratory, has been heading that up once we managed to arrange the funding through the European Commission. That was bringing together the various databases and establishing what was going on a broad aspect. Thirdly, there was an initiative which brought together originally France, Germany, Italy and the United Kingdom, which brought together not exactly the same bodies as ACTIN, because they are different. For example, in Germany the FNR is funded by government to the tune of DM50 million per annum. We were looking at a government contribution via BBSRC of £100,000 per annum—a major differential. We brought them together in a group called the European Renewable Raw Materials Association, which is now expanding further to take in other groups. So I would want to place on record by going through this rather tedious detail that we at the NFU have sought to be proactive in bringing together the various bodies because we see this as a major part of the agricultural mix in the new millennium. Thank you.

39. Thank you very much indeed. We have obviously received a good deal of background statistical material on the state of the market, but could I start by asking you—and, indeed, if your colleagues would like to add anything we would be grateful—how you personally see the market for non-food crops developing over the next ten years, and in particular which non-food crops you expect to be significant in terms of economic activity, all activity but in particular economic activity?

(*Mr Gill*) Given that we do not have political uncertainties coming in here, which can get in the way at times and cause the eye to come off the ball, there is substantial potential for the development of non-food crops across a broad spectrum of activity in the next decade. Indeed, it was the first report of the Government's Technology Foresight exercise which envisaged a scenario in 2015 where we would be growing what they call designer crops for farming, but the farming was spelt with 'ph' rather than an 'f'. These may be niche products involving small 10 hectare, 25 acre, plots, but in addition there was an enormous potential in the major commodity areas, not just for energy, which is being developed, but in a broader spectrum of renewable raw materials. Could I ask Ian Bartle to add to that and then Andrew Hebard.

(*Mr Bartle*) Currently I think we need to look at this on a global basis because crop-derived raw materials as feedstocks for industry is not a new concept. In fact, before the Industrial Revolution when we discovered all these fossil fuels, crops provided all mankind's needs for fuel, shelter, clothing, warmth and medicine, but currently there are about 50 million tonnes of material produced from crops under the categories of oils, starches and non-wood fibres, in other words, not forests or paper-making, and these go into a number of different applications—oils for making soap, starches in the paper industry, fibres, again for the paper industry. We have taken soundings with the relevant bodies in Europe and extrapolated to a certain extent on a global basis, and it would seem that over the next five years there is a belief that the use of these materials will increase by 30 or 40 per cent., more so in the oils sector, where there are opportunities for lubricants and surfactants produced from these oils, and starches can be used to make things like biodegradable plastics. In fact, my colleague Phil Taylor might like to say a bit more about the use of starch in the manufacture of paint, for example, and in the use of fibres again for paper and packaging materials. So we have quite a solid base from which to operate but there are significant opportunities depending on the drivers for change, which we may debate later.

Lord Porter of Luddenham

40. Could I ask, was the 50 million tonnes worldwide?

(*Mr Bartle*) Yes.

41. And that includes fuel products?

(*Mr Bartle*) No, this is only materials.

(*Mr Hebard*) With regard to the United Kingdom, the outlook, our company is heavily involved in the development of new crops that we see as being tomorrow's industrial feedstocks, principally for speciality chemicals and industrial chemicals. Quite a good example of how we have seen that market grow is that ten years ago there was virtually no production in the United Kingdom of a crop called high erucic acid rapeseed. Today the United Kingdom is the leading producer worldwide of this particular crop, which is a feedstock for the amide industry, for example, as a slip agent for plastic bags. That has been a good foundation to look at other new crops with speciality chemical constituents that will go into industrial feedstocks, pharmaceuticals and other polymer-based industries. We are working on two or three crops that we believe over the next ten years could be substantial, and by substantial I mean equivalent to the high erucic acid rapeseed area, for these novel applications. It is difficult to say the market size at the moment because this is partly speculation on where we think the economics will be, but regardless of area, the important thing is that it is wealth-generative. As Mr Gill said, it is not just a case of these being large acreages; they are also very high-value feedstocks as well, which will bring investment opportunities in intellectual property, patents and probably employment.

(*Dr Taylor*) I think the point that Andrew made is very valid, that you need to look at different sectors. There will be a sector which will be growing for a very high added value. It may be quite a small acreage but there are opportunities, as we begin to see in the bulk chemical industry, for significant land usage, not necessarily very high added value but we can actually use up significant amounts of land in beginning to replace the petroleum feedstock in some of our bulk materials, our bulk paints and bulk plastics. I think we are going to see a slow growth over the next few years, and then it will gather pace as the consumer

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begins to realise this is an important area that he or she wishes to see materials from. We are trying to gather confidence at the moment that we can actually do it without sacrificing quality. So there is a small area growing very high added value but there is a large area of growth for more commodity chemicals and I think both could be valuable, certainly in the United Kingdom. We must take advantage of both opportunities to keep a broad spectrum approach.

Chairman

42. Is the implication of what you were saying about consumer attitudes that these were products that were competing, as it were, on image rather than on cost?

(*Dr Taylor*) They are competing on image. They will probably compete on both factors. Cost is absolutely vital. We have to keep the costs within the range of the current materials that we use, but you are just beginning to see with some consumer goods people are marketing based on renewable raw material. It is difficult to tell how much extra that sells at this moment in time but as people begin to understand, or think they understand, what sustainability means, the renewable material has a contribution to make towards that debate. But one of the major issues you might like to consider is that we need to be able to convince ourselves scientifically through Life-Cycle Analysis that if we move to these materials we are going in the right direction environmentally. The small amount of evidence that is available says we probably are but I have not seen enough hard evidence to convince me yet that it is a definitely proven case. I think it will be but there is a gap in the scientific knowledge base at the moment.

(*Mr Gill*) Chairman, could I add, to fill that up, because the question is about the 50 million tonnes, the energy slant of it.

(*Mrs Wright*) I think that you can split non-food crops down into industrial crops and energy crops and I would like to pick up on the energy crop side of things. The energy crop which has the most potential in the United Kingdom at the moment, we believe, is short rotation coppice. I think that it has been recognised by decision-makers in the European Commission and the European Parliament and also in the United Kingdom Government that short rotation coppice does have a lot of potential and a lot of benefits for society and for farmers. It has been recognised in the European White Paper on Renewable Energy; it was also recognised in the United Kingdom Climate Change Programme consultation document that came out from DETR a few months ago, and, of course, it was also recognised in a paper that was published by DG VI, the Agriculture Directorate, on non-food crops in the context of Agenda 2000, where all three of these papers have pointed to short rotation coppice as having a vast potential, not just for reducing our use of non-renewable raw materials, fossil fuels, but also for adding to sustainable development, rural development and giving farmers a whole new market which they can supply. The European White Paper, *Energy for the Future: Renewable Sources for Energy*, estimated that the European Union renewable energies target will require 6.3 million hectares of SRC to be planted, energy crops to be planted, by the year 2010. So we feel that there is great potential there.

(*Mr Gill*) I should declare that I am growing short rotation coppice myself and I will be growing industrial oilseeds this year again.

Lord Soulsby of Swaffham Prior

43. I was impressed by Mr Gill's major statement that non-food crops will be a major part of the agricultural mix in the new millennium, which is very interesting to hear, but Mr Bartle touched on the international dimensions and my question really is, despite the fact that it will be good to have a good mix, can we compete on the international market in terms of growing these non-food crops, in terms of energy, in terms of manpower, in terms of marketing? Are we in a competitive position in this country to grow them competitively on an international basis?

(*Mr Bartle*) In terms of crop yields we have some of the best in the world, certainly for wheat and oilseed rape, which are two of our major crops. In terms of the technology to support the development of the uses of these crops into industrial applications, we certainly have a very strong scientific base and a willingness from industry to take up these opportunities. In terms of cost of the materials, then with each successive round of CAP reform which reduces the support prices for commodities like cereals and oilseeds, bringing them nearer to world market prices, we should be able to compete. I am very pleased, though, that you raised this issue of competitiveness because only yesterday a report came to my hand from the American Soya Bean Association, and this is a fairly substantial document, as you can see. They are evaluating the opportunities for soya bean oil, which will be a competitor to rapeseed oil in markets such as lubricants and hydraulic fluids. This report was produced in January 1997 and I will just read one sentence from it to indicate that they are looking at us even though at the moment we may not be looking at them. They are currently a little bit behind us on technology and it says: "This [delay] can provide an opportunity for soya bean oil-based technology to catch up to the rapeseed oil-based experience and compete for the large US potential." So the USA recognises the opportunities here and it will be a competitive situation.

(*Mr Hebard*) One of the biggest hurdles to long-term development is of industry confidence in the development of these crops. Clearly the United Kingdom has some of the best farmers in the world and some of the best technology for developing new and alternative crops. I that think right the way through the supply chain the biggest hurdle we have to overcome is one of confidence and not economics and that is witnessed by farmers being reluctant to invest in the technology to grow these crops because at the moment there is a differential subsidisation of some crops versus other crops. Therefore, in basic terms a farmer in the United Kingdom has a higher profit expectation than a farmer in North America. Therefore, there is more risk associated with going

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into the new crops in the United Kingdom than there is in North America. That is the first hurdle from a confidence in the grower point of view. The second one is the confidence of the processor. Can he be assured of continuity of supply of feedstock, because if the grower is not prepared to invest then the processor simply will have the same problem. Is he going to be guaranteed this chemical feedstock in five years' time, and that is a big problem. Of course, finally there is the consumer, the person who is buying these raw materials for manufacture into the end product. Is he going to be assured of feedstock in five or ten years' time, and how will political intervention impact upon the supply chain over that period. I think that is the biggest hurdle. On the economics, as we see it at the moment and as Mr Bartle said, it looks as though the United Kingdom can be a competitive long-term supplier of these materials.

(*Dr Taylor*) Another thing to mention in order to get us ahead and keep us ahead is the speed with which we can put the linkages in place between the farmer, the technologist and our industries to draw it through, and I suspect we will draw it through at low levels to begin with to gain this confidence. Once we have established those linkages we can actually move forward together. So it is important that the United Kingdom base has a strong linkage to bring the quality through together quickly, otherwise, as has already been said, if America or Japan establish those linkages before us then there will be a race. If we have the linkages we can get in first, we can patent protect or whatever and be of benefit to the United Kingdom.

Earl of Selborne

44. I would like to follow up Mr Hebard's interesting point about profit expectation in agriculture. Presumably it is declining, the profits do not look very good, so perhaps that is on its way to being resolved. To what extent are there long-term contracts being put in place? Clearly with these developing high-value crops there needs to be a degree of confidence and contracts effectively between the producer and the industries which are going to use these materials? Are you developing long-term contracts and are they working?

(*Mr Hebard*) Yes, we are, and yes, they do work. We have a greater demand from growers for the security of long-term contracts and we are typically working on three-year contracts now, supply agreements for three years, which cover from field to factory, so we supply the plant and seed to the farmer and then the raw material is harvested from his crop, with price guarantees and profit margins built in there for the grower. The problem is going beyond three years because of political impact upon our business. We do not know what that is going to be. We cannot make guarantees beyond that because of the impact of things like set-aside, which we will come on to later.

(*Mr Gill*) I think it is a crucial point because I can see that if we come into speciality oils to prevent cross-pollination from volunteer plants we will probably have to consider farmers being tied up on a longer-term basis, that you will decide to specialise in one particular area and there will need to be some long-term commitment there, unless we can do it through biotechnology, breeding ways as to energy or other mechanisms in there, but in terms of the energy crop it is quite frightening that I have signed up to a 16-year contract to supply short rotation coppice to Project ARBRE, which takes me to retirement.

Lord Soulsby of Swaffham Prior

45. If we could turn to regulation and support, which in a way also deals with the question of confidence, if the Agenda 2000 proposals relating to arable payment and the zero rate of set-aside were to be agreed, would this have a significant impact on growing non-food crops in the United Kingdom?

(*Mr Hebard*) I think it is a big step forward in that it does allow the ability for farmers to take out voluntary set-aside in any one year and make the decision as to whether he wants to grow industrial crops. It does not, as I understand it, provide for a long-term mechanism, though, that may give him confidence over a five-year period or a ten-year period to have that stability, knowing that a percentage of his land will always be guaranteed an income for non-food production. That is one hurdle. The other hurdle, which I think is actually a negative against set-aside and one of the concerns of our customers, is that in any one year after Agenda 2000 the European Commission can re-introduce set-aside at an obligatory level and what you will see then is farmers or merchants effectively dumping product on to the marketplace where they have grown non-food crops because they get an income from it. There is not a market there at the end of the day and we go back to the supply extremes going from the novel feast and famine, if you like, where, in the first two years, the feedstock is very hard to come by, but if set-aside is re-introduced at 15 per cent. then we will have a dearth of industrial materials on the marketplace, creating more financial instability.

(*Mr Gill*) Chairman, this is an extremely important point. Perversely, it could be argued that the ability to grow non-food crops on set-aside was not the best instrument for development of non-food crops. Although it permitted a form of payment to support the industry, what it did was engender an expectation, a false expectation, of potential and built up imbalances in supply and demand which varied with the varying rate of set-aside from 15 to 5 over the years. So that I found early on, not surprisingly and not unrealistically, potential commercial users of our product were saying, "If you want me to invest in a downstream use of non-food crops, I want to know I am going to have a supply each year. How can you do that if set-asides vary, if farmers jump in and out? Can you assure me that this is not just a short-term fad?" That is crucial to ICI, for example, to all the other companies, and that is why we have argued very strongly that in the European context we believe it needs to move into a firm base of regulation actually to give a clear indicator, to bring together the various bits we have heard from Mrs Wright, the point about the

Lord Soulsby of Swaffham Prior *contd.*]

Commission's aims on energy and other aspects. It is all right these fine statements where there is substance, and this has been added to most recently in the early hours of last Thursday morning when the final compromise document, which I am sure you have all read in detail at this stage, included in the rural development section a reference to non-food crops and the importance of them, but it is lacking in detail and I think it is incredibly important that pressure is put on the Commission—because it should be from the Commission—that this direction comes to fill out this heading, not in the way that it did in the interim report, which was incredibly disappointing, but in a positive way that meets the demands of all concerned.

Lord Walton of Detchant: Perhaps you should wait until there is a Commission.

Lord Middleton

46. My Lord Chairman, I have to declare an interest in that I am a director of a farming company, as Mr Gills knows, in Yorkshire, one of the activities of which is the production of crops for non-food uses, but my question is this, that surely, in relation to the question which Lord Soulsby asked, what is going to have a significant impact on growing non-food crops in the United Kingdom is the market. We have heard very encouraging things about the potential supply but my Committee, which Lord Soulsby was on, about nine years ago did an enquiry about this very subject and we were very gloomy about the supply situation, for the reasons we said in our report. Have things happened in these nine years that make you more confident there will really be a market for this stuff, which I am sure we can produce?

(*Dr Taylor*) The answer is yes, if we can be assured of continuity of supply year in, year out, and also throughout the whole calendar year, yes, the market is there for us gradually to make this shift. What will drive it is that either we can develop new technology, new and better systems from these materials because the molecules are just better—and we have seen a few examples of those—or else we can see that ultimately this will be a lower cost base from which to work. Currently that is not the case because oil prices are very low, leading us to a construct that can compete with oil, but given time that may all change. There is the third issue of the environmental benefits, can we actually see ways in which we can do things in a more environmentally friendly fashion, and that will enable us to sell more and to convince the consumer to buy more. Then there is the whole issue of energy utilisation. If we can eventually use plants as our chemical reactors to produce the kind of polymers or molecules we want, then yes, that has to be a longer-term driver. So the market is there but it is under the surface at this moment in time. So our work at the moment and most of industry's work at the moment is looking towards small introductions of these because we are not yet 100 per cent. confident that we can have large quantities of materials regularly year in, year out. So we are starting at the low-volume end to perhaps get our toe in the water to see what can be done but the market is there, the consumer is alert to this issue. In my own very specific industry, the paint industry, our biggest customers in the United Kingdom—the B & Qs, the Do-it-Alls, the Homebases of this world—are very keen for us to push this work forward because they see that as a strong selling platform, not this side but the far side of the millennium. So, yes, the market is there but we need some reassurance of a regular supply of material and if we hear messages like it is going to be turned on and turned off, I am afraid our commercial colleagues get very twitchy and say, "In that case, we are going to stick to oil."

(*Mr Bartle*) Chairman, as I see it there are four main drivers for change, in other words, reasons why industry might consider using these materials. One has to be cost. They need to compete and at the moment with oil prices at an all-time low, even though they moved up a little bit last week to something like $12 a barrel instead of 10, that is still a very low base from which to operate. So we are up against it in terms of direct price competition at the moment. The next thing is performance, in other words, do these materials do the job they are required to do? I know from talking to Phil Taylor outside the meeting that they could have launched an item, a paint, incorporating potato starch a little while ago but they needed to satisfy themselves that product would meet the same very high standards that they set themselves using their conventional, traditional sources of raw materials. But there are applications where crop-derived raw materials are becoming very competitive in terms of performance, one being the very simple application of chain bar lubricants in the forestry industry, where the vegetable oil, being polar, sticks very nicely to the metal cutter bar and gives high degrees of lubricity. So even though the oil itself is maybe slightly more expensive per litre, the cost of use is, in fact, less. Then there is a third driver, which is regulations, and this is obviously where the Government can have a role to play and increasingly we are seeing from Europe regulations concerning environmental and health concerns. I just cite one example, which is that there are regulations coming in to reduce the level of volatile organic compounds, VOCs, and this is moving industries such as the paints industry or the inks industry away from solvent-based products towards more water-based products, and in some instances crop-derived raw materials can provide those materials to allow them to formulate to those specifications. Finally, there is the issue of sustainability. I touched on it right at the outset and perhaps it is looking rather a long way ahead but I think the big chemical companies are beginning to recognise that crop-derived raw materials, carbohydrates and other raw materials of that nature, have a very significant role to play. There are companies like Dupont who now very strongly wish to be known as a chemicals and life sciences business rather than just a chemicals company. Certainly in my dialogue with ICI over the last three or four years I have become aware of a very strong internal drive to look at these materials, not just because of image in terms of consumer appeal but because of their ability to meet the market requirements in terms of cost and performance.

(*Mrs Wright*) You isolated the fact that there are the market developments and also the agricultural

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policy; I like to call them the "push and pull" factors. When looking at regulation and subsidy I think it is vital that it is not just the agricultural decision-makers who look at the regulation and subsidy for non-food crops. I think we need some joined-up thinking at a United Kingdom level and at a European level and I would like to feel that we could have some joined-up thinking, maybe a task force in the European Commission which would include people from the Directorates that look at energy, industry, trade, research and development and environment, because I feel that all those factors have a vital role to play.

Chairman

47. Before we move on, because I do not want to lose this issue of the impact of the support regime, I appreciate the point that is being made that the uncertainty about changes in the support regime can act as an inhibition on investment but one way of removing that, of course, which is implicit in some of the proposals, is to remove compulsory set-aside, to reduce subsidies and then it has gone; the uncertainty is not there, but are you saying that is a world that would be healthier for the evolution of these crops?

(*Mr Gill*) Of course it would be healthier if other countries in the world were guided by the same procedure but we find other regulations and other cross-subsidisation facilities lower costs elsewhere in the world. Equally, we need to have a situation here in a new and emerging industry of having funds to pump-prime and stimulate the new crops when they go through these initial periods. If I may give you one simple example, when I first started looking at short rotation coppice and the expected dry-matter yields, we were talking about 10 or 12 dry-matter tonnes per hectare per annum, the average of a three-year cycle. Some of the work now that is being done at Long Ashton Research Institute in their plots, albeit in trials, is showing yields in excess of 20 dry-matter tonnes. That dramatically alters the economics. At the same time work that has been done on the harvesting and planting methods, which are a major establishment cost, has led to significant reductions in that establishment cost. Unless we have pump-priming money of that nature, not just in this example but to encourage the development of the non-food crops, then we are at risk of losing it all. What I was emphasising in my comments about set-aside was that it was the fact that it was an area of turn-off, turn-on that actually did not create a stable environment. I think there is one other driver that I ought to mention or draw out a bit and that is the driver of Kyoto and the various international accords on the environment. The beauty of the energy crops and of the plant as a natural bio-refinery—and I use that word as a key phrase—is that it is CO_2 neutral and that is something that we should not under-estimate at this time when we have a government that is taxing fuel to address this issue and placing the United Kingdom in an extremely uncompetitive position on that basis. It would be far better if we could look at other ways of reducing CO_2 emissions by encouraging the technology with pump-priming funds, by giving consistency along this line. Equally, we can give other examples where there are other environmental benefits that would come along to help sustain the targets set in Kyoto. I do not know if you want to add anything?

(*Mr Hebard*) Yes, if I may, my Lord Chairman, specifically relating to Agenda 2000 proposals. One area there that we see as a big threat to United Kingdom agriculture is that of the non-crop-specific area payment that is written down as being the way ahead from here, which basically means that all crops will receive the same area payment, the same subsidy paid directly to the grower. It does not actually mean that. What it means is that the crops that are currently subsidised will receive a unilaterally level payment, not new crops, and we see this as a big threat, the reason being that if we discover a new oilseed, say, that may have food applications as well as non-food applications, it will not be eligible for area payment. In very broad economics that means that a crop today like oilseed rape that is as competitive as oilseed rape to grow and to process and to manufacture would cost twice as much to the consumer as oilseed rape does because the farmer receives a subsidy for growing oilseed rape and will not receive a subsidy for growing a new crop. I think the corollary to that is that we will see more genetic modification of oilseed rape plants and existing plants that are currently eligible for subsidy to contain minor chemicals and plant constituents that other plants may contain using biodiversity but will not be allowed to be grown because they will not be subsidised.

Lord Soulsby of Swaffham Prior

48. Before we move on to the United Kingdom and European Union regulations, may I ask a question about mobility of this non-food crop area. How quickly can you move from food crop production to non-food crop production? I presume it is different. Oilseed rape might move fairly quickly but coppicing might be fairly long-term, but what is the mobility in this area?

(*Mr Hebard*) Generally I would expect that to be dependent upon the crop. If it was a traditional combinable crop, if it was an annually grown crop, that transition could be within a period of 12 months. If it was a long-term crop, as Mr Gill suggested, short rotation coppice, the transition to establish a stand and produce from it would be significantly longer.

(*Mr Gill*) My crop, short rotation coppice, was planted in April 1997. It was coppiced in the spring of last year and will be harvested at the end of its third growing season, so in 18 to 20 months' time. I have to say it is a marvellous sight to behold at this time of the year. It is ahead of anything else in coming into bud. The greenery and all the pussy willows there are a tremendous asset to the environment of the countryside.

Chairman: I hope it looks as nice when you have dug it all up.

Earl of Selborne

49. I was going to refer to question 3 on your sheet, and let us leave aside for the moment set-aside regulations, Agenda 2000 and all the distortions coming out of the common agricultural policy. Mr Bartle reminded us that there are some regulations with might, in fact, be helpful. You referred to water-based products and to regulations on volatile organic compounds which might possibly help the market. Could you run through for us the balance sheet of regulations as you perceive them at the moment? Are there some regulations like that which are helping the non-food crop sector? Are there other regulations, either nationally or at a European level, outside the CAP ones, which are likely to be a hindrance?

(*Mr Bartle*) My Lord, that is a tall order but I will give you three other examples, one for and two against, and I will hand over to Andrew for the second one against.

Chairman

50. Perhaps if you would like to come back to the Committee with a note as well that would be helpful?

(*Mr Bartle*) Certainly. The other one that I would mention for is that there are some European regulations concerning the recycling of packaging materials and these increasingly have to be recycled or recovered. In other words, they have to be re-used as packaging materials or other fibres or they have to be incinerated to recover the energy from them. That might not seem a very positive driver in this area but it certainly raises people's awareness of the need for recycling of materials and the fact that we cannot continue to depend on a finite resource, which is oil. There are two discouragers which I would like to refer to. One is called IENICCS, which is the European Inventory of Existing Commercial Chemical Substances. This was drawn up in the early Eighties when we were getting more and more regulations coming in from Brussels and was intended to identify chemical compounds already in commercial use. From then on any new compound that was to be introduced into the marketplace had to go through very rigorous tests, which is all very laudable. The unfortunate thing is that when one comes to consider products such as oilseed rape or its derivatives, they also have to pass over this hurdle and in many instances these are fairly low-volume markets and the cost of registration is somewhere in the region of £150,000, which may not seem a lot if you are talking as a pharmaceutical company, for instance, but as a company operating in a relatively small niche area it is quite a barrier to progress. I know one particular example where that was one of two reasons why a particular project which could have led to the wider use of rapeseed oil was dropped. The other one was the capital cost of converting plant to accommodate this new material, which is another issue. So I would raise this as an issue which concerns us a great deal and we are actually talking to the DETR to see whether there could be some derogation of this in terms of the very low-toxic or non-toxic materials that we are talking about in terms of crop-derived raw materials. So that is one barrier. The other one is the need to put down payments to guarantee the buy-back of contract crops, and I will hand over to Andrew Hebard on that.

(*Mr Hebard*) Under the European Union regulations any grower or merchant who is involved in the production of non-food crops on set-aside has to lodge a bond or a security with the Government. That bond currently is 250 ecus a hectare. For the 1999 harvest coming up now we calculate that equates to approximately £27 million sterling held in bonds by the United Kingdom Government alone. The reason the bond was introduced was to prevent fraud by crops grown on set-aside entering the food chain. That bond is released once the crop has been shown to go right the way through the process chain and turned into what they classify as an eligible end product. That might be for the manufacture of plastic bags or chain lubricants, as Mr Bartle said. On average, that process takes between two and three years to get the security released. So if you assume that this year is representative of other years, then the United Kingdom industry may be exposed to something in the region of £50 to £60 million security lodged with the Government at any one time to make sure that fraud does not take place with industrial crops. For an industrial company such as mine where we put up this bond, we have no guarantees at the end of the day that those products or the growers who produce them are going to adhere to all the regulations and leave us exposed to the chance of not getting that bond back. That is one of the areas of confidence that I mentioned to start with, where companies, whether it is Dr Taylor's or my own, have to put that cost up. Whilst it is only a bond, it is not the physical deposit of cash, you are still vulnerable to not getting that bond back and, of course, any bank that puts the cash up for you will charge you a sizeable sum of money for doing that, and that is a big barrier to industry investing in non-food crop production, the financial burden and the risk of not getting that security released.

Chairman

51. Thank you. We must move on. If you would like to put in more detail on regulatory inhibitors that would be much appreciated.

(*Mr Hebard*) Yes.

Lord Walton of Detchant

52. You have already referred to a number of important technological developments and we would like to know what further developments would enable non-food crops to compete effectively with existing materials in the longer term, if one assumes there will be no subsidies to either. We would also welcome your views on plant modification, either by conventional selective breeding or by genetic modification. Before you answer, may I say that I was fascinated to read in the *New Scientist* of 27 February a number of comments. The first was that: "In the hands of an enlightened farmer crops that have been engineered to be resistant to herbicides could work wonders for our herbivorous insects and songbirds by enabling the farmers to let weeds grow alongside crops for longer, bearing in mind they could be eradicated later in the season, but in the hands of someone more ruthless, the same crops

Lord Walton of Detchant *contd.*]

could sterilise the landscape." Then on the next page they went on to say that in Canada there is a plant which looks just like an ordinary oilseed rape plant called smart canola, which carries genes for resistance to two families of herbicides, allowing farmers to kill off every weed in sight without fear of damaging their harvest, but this particular crop is not genetically engineered, it is simply the result of selective breeding.

(*Mr Gill*) Thank you. That is quite a long question. I think I must read that article because it has interesting points on biotechnology. Could I ask Dr Phil Taylor?

(*Dr Taylor*) To look at the technological development that will be needed to push this forward in a big way, it is probably fair to say that at the moment we are probably trying to introduce these materials into the industrial arena to a certain extent riding on the coat-tails of the food industry and have the materials available. I think what we are looking at now is what can we do to those materials, what simple process modifications could we apply to them to get materials that we can currently use. I think what that is going to lead us into is to help us identify the molecules, the materials the plant will have to produce to make this really work. Probably in the longer term it will be more cost-effective to get the plant to produce the molecules we can identify, either by conventional plant breeding processes or by the genetic modification route. So at the moment we are looking at what technology we can apply simply to what is available now in order to introduce this and gain that confidence that we have all talked about and hoping the price is at least equivalent. In the longer term what we are striving to do is to say what do we need to produce products that are either identical in quality or environmentally friendly or have a technical benefit, i.e. how do we get to compounds or materials or consumer goods that better meet the regulations that are now being rightly imposed on us. At the moment we can either meet that by using the traditional materials and meeting it that way or we can do some very minor technological developments on the kind of crops that are coming out to produce these new products, but in the longer term what we are going to say is these are the kinds of materials we think we need to make either new medicines or commodity chemicals, and then when we get to that point, three to four years down the track, those involved in genetic modification can consider how they do the genetic modification so that the plant produces that chemistry so that we can take the materials straight from the plant and use them rather than having an intermediate processing stage.

Lord Porter of Luddenham

53. Could I follow that up by asking you whether there are any particular non-food crops which have an advantage, a comparative advantage, in this country in respect of ease of production, yields, processing of the crop and so forth?

(*Dr Taylor*) Certainly two families. There are the oils, the rapeseed oil, because there is clearly a lot of potential for changing and adapting the range of oils produced.

54. In this country, because we are good at it?

(*Dr Taylor*) In this country, because we are, first, good at growing and extracting and producing, but also we have a very strong science base in terms of understanding how the oil is produced, how you change the oils to get oils of more use to the lubricants, to the paint industry and industries like that, but also the carbohydrate families, the celluloses, particularly the starches of this world, where we do grow a lot of wheat. Wheat starch can become available. It would be nice if we could have more access to industrial potato starch within the United Kingdom rather than having to look overseas for sources of that, but again we do have skills in understanding how starch is synthesised, how you change it, how you develop it. So those two areas I see as areas for the large landuse potential.

55. You said something which gives me an opening to ask something which I have been wanting to ask over the last half-hour or so, and that is about some of the remarks which have been made at the beginning of our discussion about the connection between science and industry, for example. It was Mr Gill who spoke of that and Mr Bartle spoke of the increasing ability of industry to take these crops and Mr Hebard talked about the inability because of the lack of confidence. I ask this particularly because we have another of these sub-committees which is particularly interested in the connections between science and industry and science and popular opinion. So could I ask specifically on the first statement, the inability of industry to converse with science, Mr Gill: is this an inability through ignorance or for economic reasons or what? I suppose you would agree we ought to do something about it to bring them together but what is the problem?

(*Mr Gill*) I think the problem surfaced at a conference I chaired for the DTI some years ago before we established ACTIN, where, in the second session, we had scientists saying to industrialists, "What is it you want," and the industrialists responding, "No, scientist, you must tell us what it is you have to offer." It is actually finding a medium where you can talk about what scientific routes are going on and what is possible at the same time as the industrialists describing in a parameter what it is they want. Some of this can be in a broader spectrum, for example, than just between me as the farmer and Dr Taylor as the industrial user. Let me give you an example there. We have talked a lot about oilseed rape. There are concerns that we could end up using oilseed rape far too much. Indeed, we could be risking mono-cropping to the point of problems of biodiversity, problems of disease resistance. So while the scientists will have a blinkered approach, "Let me put these attributes into rape", I as a farmer, as an industrial part of it, will be saying, "Please start looking for some other crop species." We came across that earlier with work that was being done at the John Innes looking at particular isopetroselenic acid which has been discovered in coriander, and our recommendation to them was, "Do not just think how you take the genes and transfer the capability from coriander to rape. Look at how you can upgrade coriander, more difficult that it is, so that we

Lord Porter of Luddenham *contd.*]

have a different crop plant in our species so that we can break the cycle of pests and diseases."

56. So the inability that you are referring to is an inability of the scientists to understand rather than industry?

(*Mr Gill*) Both.

(*Dr Taylor*) If I could perhaps disagree with what Mr Gill is saying, I think actually we are getting better at conversing and trying to understand each other's needs because we in industry have recognised that this is a superb opportunity for us to move technology forward using these new non-food crops, but those of us in the area recognise that we simply have not got the skills. I am also a scientist as well as an industrialist and we have really been trying to build those bridges to talk to the farmers, to the scientists, but because of the constraints under which the industry works—we have for some reason to make a profit—we have had to find mechanisms which enable us to talk in a way which is not just talking but beginning to work together. We have talked about the European Commission and what they have done. Some of the schemes they have in place in terms of helping us to work alongside, through their framework programme, have begun to break down those barriers. I think the barriers are slowly coming down. The industry recognises—and we want to understand this—that we do not have the skills; any one company has not got the skills, but I think we are being a little more receptive and open. So I think your question is very well timed, and I think the tide is turning our way but it has been turned our way not only by a willingness for us to think about doing it but also by the fact that we have found a source of money to make it happen, which is the European Commission money, I have to say.

Lord Walton of Detchant

57. As in other fields of exploitation of scientific discovery, is the lack of venture capital a problem?

(*Mr Gill*) There are always the financial arrangements in the City, which are not necessarily venture capital per se. Can I just conclude that previous point by saying that I have no disagreement with Dr Taylor because what I have described is historic and led to the establishment of ACTIN, which is the work that Mr Bartle has been doing to establish those connections.

Lord Soulsby of Swaffham Prior

58. I have a very brief question and it refers back to regulation, support and technological development. When does a genetically modified crop become a new crop? Mr Hebard said that new crops may not generate support, but if you genetically modify it, is it a new crop or is it an old crop?

(*Mr Gill*) As I would understand it, my Lord Chairman, my Lord, it would have to change the specie. The specie is defined in the regulation, and if it is still oilseed rape then that is all right. The fact that it produces high erucic acid or low erucic acid is still acceptable. However, if we were to develop it as coriander that is a totally different specie and that would not be registered, and I think that is the point Mr Hebard was referring to.

59. So at the species level it would be a crop and if you changed the species then it would be a new crop, but you can change it within that perfectly all right?

(*Dr Taylor*) That is why much of our current work is based on what is available now—known species—and what we can do to make very simple, cost-effective modifications that we can use now. If it produces a small change we can then say "Look, it can be done, it is worthwhile doing it". If we can do that then either our own companies or the venture capitalists can say "This is really worth investing in because you have given us a small piece of confidence". If we can do it at a small level we can now go for it at a big level.

Chairman

60. I realise Lord Porter's original question was quite long but I just would not want us to miss out on the first half of it, which was the extent to which there may be a comparative advantage for the United Kingdom in some of these crops. Earlier we spoke of the extent to which there might be differing degrees of support, but I wonder if we could also test this panel's views on the natural advantages or disadvantages that the United Kingdom might process.

(*Mr Hebard*) We have tried growing oilseed rape in various parts of the world and we find the United Kingdom has the lowest cost of production for oil derived from oilseed rape species. I think that is a well-recognised and well-documented fact. That is a distinct competitive advantage for the United Kingdom.

(*Mr Bartle*) I would like to refer to two specialist crops, one of which is well-established, which is borage, or starflower, and in fact it is one that is placed out on contract in large areas by Mr Hebard's company to produce gamma linolenic acid which has advantages in the health care industry. We have, I believe, an advantage in terms of the crops' adaptability and suitability for northern climates in the United Kingdom and Northern Europe. The other crops is one which is new in terms of its application and very old in terms of our understanding of it, and that is woad, which the ancient Britons used to use as a source of blue dye. Under the link programme that I co-ordinate we have a particular project which is looking to improve the use of natural indigo produced from woad, in this first instance, to produce inkjet inks used as water-based ink in printing labelling in the food industry. It is quite obvious, if we are successful in this, that there are other applications in the textile industry, and then the market starts to open up considerably. Because of its adaptability to the United Kingdom climate we believe this crop has quite a good future. We calculated that if we were to produce 10 per cent of the natural indigo market for Europe in the United Kingdom then we would need to plant some 16,000 to 20,000 hectares, which matches the sort of area we are talking about for the high erucic oilseed rape at the moment.

Chairman *contd.*]

61. What about energy crops? Are we naturally advantaged or disadvantaged?

(*Mrs Wright*) On the west side of the country, particularly, we are advantaged because, as you quite rightly highlighted in your document, post-125, one of the disadvantages of energy crops is that they do require a lot of water and on the west side of the country—Wales and Cumbria—there is high rainfall. There is also, let us not forget, the potential for destocking—farmers coming out of livestock—in that area. So there could be land availability in the very near future for energy crops. One of the other things about the United Kingdom and energy crops is that we have had tremendous support from the Ministry of Agriculture in both lobbying and in the amount of funds that have been spent on research and development.

Earl of Selborne

62. Could I ask on that, specifically, does it mean that the ARBRE Project has been put in the wrong part of England?

(*Mr Gill*) The answer, of course, my Lord Chairman, is—and I declare my interest since I am supplying it—no. The rainfall is better in the west but it is the soil types that are crucial as well. There are other projects going on in the west.

(*Mrs Wright*) There are a number of contracts out for projects on renewable energy in power plants, which would be on the west side of the country. On an aside, really, there is another problem there because there is a powerstation that was planned in Newbridge-on-Wye in Wales, but unfortunately the developers hit a lot of problems when they tried to get planning permission. The National Farmers' Union have been trying also to lobby for support for clear planning policy from Central Government to Local Government to ensure that the planning officers can realise the benefits of renewable energy powerstations.

Lord Porter of Luddenham

63. I would like to ask Mr Bartle—it is a bit peripheral but it comes out of this discussion—what are the driving forces for energy crops? He said specifically that the limited resources of oil must be taken into account. The other two would be CO_2, I suppose, and economic reasons, but I wanted to ask, on the first one, is it a real drive, at the present time, that oil is going to run out sometime?

(*Mr Bartle*) My Lord, having talked with my NFU colleagues I understand their current main driver is on CO_2 emissions, but that does not detract from the fact that in the longer term oil is finite in its resource. In fact, I read a report published in *Scientific American* last year which carried out a very in-depth analysis of oil reserves and was saying that over the next decade oil production from conventional sources will peak and then decline irrevocably. In other words, we are on a bell-shaped curve, we have used up half our oil reserves, and, probably, in the next hundred or so years we will use up the remainder.

Chairman: I think we are rather straying into matters of another inquiry. Perhaps we should come back to the focus of this Committee.

Lord Birdwood

64. ACTIN is a business accumulating useful data, and I was curious about the environmental and ecological implications of the development of these crops. The kind of areas I want to reflect on are toxicity residues, soil exhaustion, landscape visual degradation and, on the plus side, bio-remediation.

(*Mr Bartle*) You say "on the plus side bio-remediation" so you regard toxicity as a problem?

65. No. What evidence is emerging for toxic residues as a result of non-food crops, if any? What evidence is emerging of visual degradation of the landscape, of soil exhaustion, if there is any? Then I said, on the plus side such aspects as bio-remediation, as an ecological issue for the restoration of brown field areas of the cities and such like.

(*Mr Bartle*) Non-food crops would be grown in rotation on a farm as any other crop. If there has to be some isolation because of fears of cross-pollination or whatever between different crops (and I am not talking about genetically modified crops here, I am talking about cross-pollination, perhaps, between high erucic rapeseed and double low rapeseed, which for food uses have to have less than 2 per cent of erucic acid in it). So already we have these problems of segregation to deal with. I am not aware of any problems with toxicity from non-food crops. In fact, they are, by their very nature, non-toxic; they are biodegradable and they are CO_2 neutral, as we have said. I would like to give two examples of where, perhaps, moving from chemical syntheses towards crop-derived raw materials is going to reduce the risk of toxicity. The woad project that I mentioned would be replacing synthetic indigo which, at the moment, is made from aniline, formaldehyde and hydrogen cyanide, using a batch process. This comment came to me from Long Ashton Research Station, and at the bottom it said that this can hardly be described as a wholesome combination, which I would endorse. I would also quote from a letter I had from IACR Rothamstead who are "working to develop novel crop protectants that work by non-toxic mechanisms". Their first example is, in fact, that they are developing an attractant which they are extracting from cat mint and they are then going to be spraying this attractant on to crops at a time when there is a build-up of the aphid population, and the objective is to attract in parasitic wasps which would then control the aphid population. So we are, therefore, developing biological control systems using non-toxic chemicals. For those two reasons—and I could go on—there are, I believe, very sound reasons to believe that crop-derived raw materials are non-toxic. In terms of bio-remediation, that is not an area that we have devoted a lot of time to, but I am aware—again from Rothamstead—that they are developing what they call hyper-accumulator plants which can capture heavy metals and, therefore, return land that is being degraded to, perhaps, agricultural production.

Lord Birdwood *contd.*]

(*Dr Taylor*) Can I just comment on that? I think, to a certain extent, in relation to environmental implications, we are always in a Catch 22 situation. We will not know, until we have got systems up and running fully, what are the environmental issues connected with going down this kind of route. Once we have got these up and running then we can do Life-Cycle Analyses and understand what the benefits and disadvantages are. Where we are at the moment, we do not have a system and we do not know what the pluses and minuses are. Our viewpoint is that we would like to have a possible or alternative which may well be better but until we set out and try it—if we try it and it is not better we can say "Okay, we have tried and looked", but the concern is that we do not know. We think it should be better but until we begin to do the work and define the kind of processes that are needed—if you have a process in place you cannot do a Life-Cycle Analysis on it. That is the problem. So there is a little bit of a Catch 22 situation; we all feel it should be better—more CO_2 neutral or more environmentally friendly—but we have not got the hard evidence yet to actually prove that. That is why it is a little bit of a risk-taking exercise. We assume it is going to be better and if it is then I am glad we went down this track, but if it is not then at least we know it is not; we have investigated and found out before it is too late.

Lord Birdwood

66. My Lord Chairman, may I ask a very brief corollary? That brought me back to your database management, and I was wondering whether its architecture was friendly towards data-mining techniques so as to introduce some kind of predictive capability for unexpected correlations?

(*Mr Bartle*) Thank you for that question. It is something which we are giving some thought to. The database has been built up over the last two years or so. It is accessible by using key words on crop species, products and molecules, and skills and disciplines. We are aware that we could use this data-mining technique, time and resource allowing. We have already done a manual comparison of apparent industry interests, market sectors in which they are interested and the research programme that might support those market sectors. We believe that we have identified one particular sector which is using crop-derived materials for polyurethane, and we need to do some more work. As a result of that, with funding from the Home Grown Cereals Authority we have a project in place. The potential of this sort of data-mining, as you say, is something we are aware of.

(*Mr Gill*) We have made available the password to the Clerk of the Committee, or the Specialist, for you to use the database if you so wish.

Lord Rea

67. Dr Taylor, you twice mentioned Life-Cycle Analysis in the context of it being too early to assess the total impact of non-food crops because we have not done it on a sufficient scale or it has not been going long enough. With a view to the fact that this is actually a theoretically very sound method of measuring total impact, do you think there should be a concentrated Life-Cycle Analysis programme within this country or in the European Union? Can you expand a little on that?

(*Dr Taylor*) Yes, the basic tools of Life-Cycle Assessment are well-developed and they are available. I do not think we have yet applied them vigorously enough to the kind of processes we think will apply right the way from the seed through to, say, a can of paint. We do not yet quite know how all the bits of the jigsaw are going to fit together. I think it must be done because we are going to have to check this out rigorously before we go down that track. The tools are available but we need some co-ordination, some driver, to make this happen. Quite where that driver comes from I cannot work out at the moment. Bits of the cycle have been studied and there has been some fairly in-depth analysis done on some of the materials, so we can see some of the pluses and minuses. We are probably now in a position to actually begin to do that analysis. Yes, I think it is a valid point and I think now is the time. So it is alongside all the technical developments that this kind of skill is applied to these kind of things, and whether it is a United Kingdom or European initiative I think we can debate, but, yes, the tools are there.

68. Do you think there should be an initiative coming from Government or do you think an organisation such as ACTIN should start the ball rolling?

(*Mr Bartle*) My Lord, yes, the importance of Life-Cycle Assessment and cost-benefit analysis was raised at a workshop that we held just before Christmas, in November, and we are aware that there are two groups in the United Kingdom and one in Denmark that are carrying out quite a number of projects on this subject. They have told us that there is an organisation called the Society for Environmental Toxicology and Chemistry (SETAC), under the auspices of which these tools are being developed. So there is already some activity in this area. I am aware that I believe it is a MAFF-funded project is being conducted at the University of Reading and there is also the opportunity for funding coming from the European Commission under their Framework Five programme in this area as well. I am not sure that it is something that ACTIN would need to initiate but certainly we would wish to encourage it.

Chairman

69. How robust are the results? Tools are one thing, but what confidence can you have in the robustness of the results?

(*Mr Bartle*) This is a very good point, my Lord Chairman. At the moment, many of the assumptions that are used in constructing the Life-Cycle Assessments are very subjective and, therefore, it is possible to influence the outcome of the analysis in the direction that you wish. I think there need to be some well-developed protocols which are signed on to by the European, international community, recognising what assumptions can or should be made

about certain aspects of life cycle, from cradle-to-grave, of any given product.

70. Presumably one of the drivers, or, indeed, one of the disciplines, will be commercial, if paint manufacturers are going to claim their products are environmentally friendly?

(*Mr Bartle*) Yes, that is why the current drive is that we would not make such claims. We might say a product can do something technically better, and it can meet a particular regulation, because we are sure about that, but we would be very hesitant about saying "This is a more environmentally friendly paint or plastic" until we had the evidence, because we are challenged more and more. That is why we are very keen to see this happen. There is scope within the new Framework Five to do fairly vigorous scientific work on this, but I think we will, in any way we can, encourage this to happen to give us, as you say, the tools. We are a bit uncertain about whether we can risk making such claims, even if we believe it is true, because if somebody says "Prove it" then we come a little bit unstuck. However, I think the expertise is available.

Earl of Selborne

71. I wonder if I could revert to a slightly different environmental issue, and that is landuse. We read in the *Financial Times* last week that some analysts think that 150,000 to 200,000 hectares under short rotation coppice might be realistic. If that were to provide just one very large powerstation, as they suggest, this has considerable implications for landuse in that area. Clearly, there is great resistance, usually, in an area when sudden landuse changes take place—unexpectedly, usually. One thinks of Sitka spruce in Wales, or, for that matter, oilseed rape, which came rather rapidly. There are implications for landuse and, also, implications as regards habitats. I wonder whether Mr Gill would comment on that, particularly bearing in mind his experience. You must have made quite a considerable impact on habitats on your own farm.

(*Mr Gill*) It has indeed. I think it refers back to Lord Birdwood's question that sensitivity of site is crucial. Some of the initial planting of short rotation coppice crops, if I remember correctly, in Northern Ireland, went over the hilltops and were not particularly pleasing to the eye. We are back into the problems that you describe of the plantings of woodland and the problems that occurred 40 or 50 years ago and that have been much criticised. By sympathetic planting of coppice with contours you can blend into the countryside in a very beneficial way. My own particular field (I have only one field) is built round an existing woodland, so it effects a dramatic drop-off from the high levels of mature deciduous woodland through into the coppice, from 16 or 17 feet high and giving a gradation down. In terms of wildlife, the Game Conservancy Trust sometime ago did some considerable work on that and the bird populations retained are quite phenomenal. Because of its density it provides a marvellous habitat for nesting birds. There has been some very interesting work done showing that. In terms of the logistics, this is a potential problem if not done sensitively. In the case of Project ABRE—I forget what the radius is—I think it is 30 or 20 miles from the centre so it is quite a diffuse area, and from memory I think it is 7,000 hectares that they wanted. That is consistent with the logistical exercises of another crop I grow, which is sugar beet, supplying the factory in York. There is a logistical exercise involved there, so it needs to be done sympathetically. We need to look at the infrastructures there. I believe that if we go into these projects with our eyes open we can address these issues in a sensible way, and, indeed, it may be arguable that one of the major potential sources for the use of short rotation coppice would be in the more remote areas where alternative energy sources are not necessarily as cheap as they would be with mains electricity in inner city areas, where you are looking at alternative ways. If, for example, you are comparing against bottled gas as an energy source then factors become very different. There is work being done on quite small gasification plants that come out very economically. So I understand the concerns, I think they are real, I think they need to be taken into account in terms of planning, but I do not believe they are insurmountable.

72. Just on this last reference to planning, are you suggesting that the local planning authority should be involved in the determination of landuse for these crops?

(*Mr Gill*) I am not suggesting that. I am saying where it has happened is in various prescribed areas—environmentally sensitive areas, for example—around the country, or whatever. We have had problems; planners there have refused developments, (for example, I think in the South and West) I believe, for the wrong reasons, simply on a blanket approach without really looking at the situation. Equally, there have been problems with grant approvals within MAFF, in looking at the South-west in the National Parks, where you have constraints that cause, to my mind, short-sighted decisions to be taken.

Lord Walton of Detchant

73. A brief follow-up on that point, my Lord Chairman. Is it possible to plant short rotation coppice on marshy land which could never be used for planting other crops?

(*Mr Gill*) It depends what the water table would be. I think it would not be necessarily very easy to do. Not least of which, you have the problem of harvesting.

74. Quite.

(*Mr Gill*) The coppice forms a marvellous, dense root system just below soil level which actually can be a marvellous filter if you are applying sewage sludge.

Chairman

75. I have two follow-ups: one is that the planning authorities will, of course, be involved with respect to siting, as was mentioned earlier, in relation to powerstations. That leads me to another question about a simple piece of analysis, before we run too far

Chairman *contd.*]

down the track of CO_2 neutrality, which is the use of equipment to harvest and transport to powerstations. Has a robust piece of analysis been carried out on short rotation crops, building in the energy use of equipment connected with the process of harvesting and delivering to powerstations?

(*Mr Gill*) In terms of CO_2 usage I have not seen one recently at all that would be robust. In terms of energy-in to energy-out there have been a number of pieces of work done which are somewhat outdated now but have suggested that the energy balance, including those remote parts as the energy going into the manufacture of the tractor that you may use, is as great as 30 to 1, which is quite tremendous. That work must be six years old now. Since then, with the increases in yield that there have been, that would improve even further.

76. It would be very useful if you could point this Committee to that recent work.

(*Mr Gill*) We will try and find it. In fact, I am sure we can.

Lord Soulsby of Swaffham Prior

77. One quick question about harvesting coppice on marshy land. I appreciate the problem with machinery but what about horses? Could you use horses to harvest that?

(*Mr Gill*) Again, with all these new crops it is a matter of getting the costs down, and the concept is that they would be mechanically harvested. So while you could use the horses to remove the coppice from the land, mechanical harvesting would still not be feasible, as, indeed, there would be a problem with trapped vehicles; certain coppice varieties tend to coppice horizontally out and you would find, with trapped vehicles, you are damaging the crop.

Chairman

78. Mr Gill, I am most grateful. Is there anything you or your colleagues would like to say in conclusion?

(*Mr Gill*) My Lord Chairman, my Lords, we are enormously grateful for your interest in this subject. I do not underestimate the enormous potential that I see in this area. I have repeatedly said, in many fora, public and private, that it is a crucial use of British agriculture in the next millennium. Without it, that balance will be far less secure. The old adage of "all your eggs in one basket" applies to much of British agriculture as an exclusive dependence on food production. We are, as Mr Bartle said earlier, simply re-inventing the wheel, because we used to do much more many years ago. Indeed, at the end of my farm drive (which I do not know whether Lord Middleton knows or not) there is a building complex which is currently a multi-requisite farm co-operative store, but it was always known to me as the flax control (?). It still has the retting tanks there to prove it. It is marvellous how history repeats itself, but we have the potential here for a significant green dividend to come from agriculture that will benefit farmers, will benefit rural communities, will benefit the economy and, most importantly, also, has an enormous potential, in my mind, to benefit the environment. I am confident that a robust Life-Cycle Analysis will prove that. Thank you.

(*Dr Taylor*) I would like to reinforce what Mr Gill said. Again, we in industry do not want to put all our eggs in one basket; we do not want to be dependent on petroleum sourcing and we need to have an alternative to see what it can offer. We also see great benefits in the longer term. We need that dual stream.

Chairman: Thank you very much indeed.

TUESDAY 30 MARCH 1999

Present:

Birdwood, L.
Hogg, B.
(Chairman)
Middleton, L.
Nathan, L.
Porter of Luddenham, L.
Rea, L.
Selborne, E.
Soulsby of Swaffham Prior, L.

Examination of Witnesses

MR JOHN HOBSON, Director, Hemcore Limited, and MR NIGEL BAZELEY, Director, Robin Appel Limited, called in and examined.

Chairman

79. Welcome, Mr Hobson and Mr Bazeley, we thank you very much for coming to give evidence to this enquiry. I think you will have had a list of possible questions, which judging by past practice, we will more-or-less stick to, but may I start by asking if either or both of you would like to say anything to the Committee by way of an opening statement.

(*Mr Hobson*) No, I do not think so. I would just like to give a background to the hemp industry within the United Kingdom when we start. I think, when we start the list of questions, to give some background would be useful.

(*Mr Bazeley*) Just to say that we have been involved in the flax crop since 1992. We are involved in the growing of it—in other words, contracting farmers to grow the crop for us—with the processing of it, and also the marketing side.

80. May I then start with you, Mr Hobson, if you would like to give us some background and describe the main industrial uses for hemp and flax fibre. Perhaps both of you could describe the extent to which you think the markets for these products are likely to expand.

(*Mr Hobson*) Hemcore, the company which I represent, started trading in 1993, when we were the first to gain a licence from the Home Office to grow *cannabis sativa*, hemp, in the United Kingdom. This was to be varieties of hemp which held a negligible drug content. That is, that the varieties must hold less than 0.3 per cent THC, tetrahydrocannabinol, which is the psycho-active drug within cannabis. That is .3 of 1 per cent, so it is virtually negligible. There is a French plant breeder who has, through basic plant breeding not genetic modification, produced these new varieties of cannabis that hold little or no drug content. These varieties are supported by the European Union and it is on those varieties that growers can gain subsidy. So in our first year in 1993 we planted some 1,500 acres and, at the same time, set up a processing plant in Essex. That processing plant was to separate the fibre on the outside of the stem very much like a banana skin, a protective coating, from the woody inner core or pith of the plant. Hemp is a plant which is planted in late April to early May. It is a spring sown plant. It has phenomenal growth. After planting through to harvest, which is in mid August to early September, the plant is capable of growing on average eight to ten feet and in some cases to 15 feet in height. It puts on large biomass. It is grown without the use of any agri-chemicals whatsoever. This really is very rare in agriculture today and adds to hemp's very green and environmentally sound credentials. The crop after harvest is stored on growers' farms until called off for production in the factory. In the factory, as I say, we separate these two main fractions. The main markets for these products right now: the woody core is sold as a horse bedding, a horse litter throughout the United Kingdom, the near continent, and we now have some very good export markets opening up in the Middle East, Finland, Malta. The horse bedding is sold in competition to wood shavings and cereal straw, which most horses are bedded down on. The main advantage is that it is a much more absorbent material than those of its competitors. Importantly, it rots down very quickly after use. Wood shavings take a long time to decompose but this rots down into a really good garden compost or agricultural compost. For example, we are doing all the horses at the Royal Mews at Buckingham Palace, where their waste goes to the London Allotment Association and to Kew Gardens. The gardeners are very pleased with this so it has been a very good product. The fibre on the outside of the stem: when we started in 1993 we only had one market available to us and that was the paper industry. But it was a specialist part of the paper industry and it was the part of the industry which was producing cigarette tissue, the paper on the outside of the cigarette. It is used within the paper industry. It was used because the fibres within hemp are very long and strong and you could produce a very thin sheet of paper. These days you can easily produce cigarette tissue from wood pulp; and hemp and flax are still being used, really only within the cigarette industry, because of the taste. It gives a taste to the cigarette apparently and the cigarette manufacturers are very worried about losing market share in these difficult times and they do not want to alter the taste of their cigarettes; so hemp and flax are clinging on in that cigarette tissue industry. We have, since 1993, tried to develop the market further, knowing that the cigarette industry was not going to be long-term. We have targeted two main areas. One is the automotive area, where hemp and flax fibre have been used to produce interior door panels for cars. This has been led by the German automotive manufacturers. Germany, as you know, is a very green and environmentally conscious nation and the automotive component manufacturers there have

Chairman *contd.*]

been keen to use natural fibres within their cars. I can go into more details on those products later if you so wish. The other area—and this is the area which has probably got the most potential—is in the replacement of glass fibre in the reinforcement of composites. There are specific advantages with natural fibres in that they are lighter than glass fibres. Think of the advantages for the automotive industry in particular. Importantly, natural fibres are cheaper than glass. There is less energy involved in producing natural fibres over glass. They are more environmentally friendly or more friendly to the operator, particularly when an operator is cutting or sanding a composite which has been made with glass. Glass can be an irritant but not so with natural fibres. Most importantly, when you want to get rid of that part—if the part was, for instance, cremated instead of just chucking it into a hole in the ground for landfill—with natural fibre reinforcement there would be no waste at all. Whereas if you cremate a glass fibre reinforced composite, you are left with quite a high residue of ash. So those are really the main markets that we are now going for. We see a great future for hemp because it is a very environmentally friendly plant and it can put on large biomass in this temperate region. It is suited to the northern European climate.

81. Thank you very much. May I, just before we pass on, because I do not want to miss it, the first market you described of horse bedding, how does it compare in price with cereal straw and wood shavings?

(*Mr Hobson*) It is a product which needs selling because, bale for bale, hemp bedding will always be more expensive than woodshavings. However, once the user has got the bed down, he or she uses half as much hemp litter to top up the bed wood than wood shavings because of its greater absorbency. So after a few weeks it will be more economic than the competition.

(*Mr Bazeley*) I think there are many similarities between flax and hemp. There are many similarities between our business and that of John Hobson in that we started at a similar time in terms of our businesses. We are talking to the same farmers who are growing the crops and we are talking to the same people who are in the markets for buying our products. Both hemp and flax are stem fibres. They both have the characteristics of being very strong compared to other natural fibres and to synthetic fibres. Certainly, as an illustration, the natural fibres, hemp and flax, have a very good strength for weight ratio. In other words, they are stronger for the same weight than glass fibre or some of the synthetic fibres. Our involvement in the flax crop was actually born out of, to some extent, our involvement in the linseed crop, which we have been working with for about 15 years. Because linseed and flax are the same species, there are obvious similarities. Linseed is grown to produce the seed for the oil, and flax is grown to produce the fibre for various markets. Having said that, flax produces seeds and linseed produces fibres so there is a cross-over, although not necessarily a straight line. Our particular involvement in fibre flax was born out of a belief that new markets were developing and would continue to develop for natural fibres. In fact, the same markets that you have just heard about. The speciality paper market is very important to us. We have actually targeted the main thrust of our marketing efforts towards the non-wovens which cover a range of products. It is a non-woven fabric, or felt if you like, which can go anywhere from geo-textile, a roll of felt matting which is rolled out beside the motorway embankment to help stabilise the soil, to what we call a tree spat, a square metre of this fabric is put round the base of a young tree instead of plastic or materials as a mulch to stop weed growth. Or another market, which at first sight may not sound desperately interesting but we have discovered is quite significant, is that of hanging basket liners. By their very nature they are replaced every year, and we are currently producing a fibre which is turned into matting, which is being sold as hanging basket liners. These are coarse non-wovens, where the specification of the fibre does not have to be that great. Certainly we believe that some of the major opportunities, which are just beginning to happen now, are both in the automotive industry and in the insulation industry where, as you have heard, the characteristics of the fibre make them interesting particularly to car manufacturers. Car manufacturers are perhaps not renowned for being environmentally aware and conscious, but I think that what started out as an interest in natural fibre or, (maybe I am being cynical) they wished to be seen to be doing things with natural products, has turned into something totally different where the technical characteristics of the fibres have actually proved themselves. Certainly all of the major German car manufacturers are now using flax and perhaps hemp in their cars: whether it is in the interior door panels or car boot linings or parcel shelves, where there is either a lining or a moulded product. At the moment, as far as I am aware, none of the manufacturers in this country are currently using flax or hemp to any significant degree only for trials and development, but we hope that will change very soon. So the automotive market is potentially a very important one for us. It is now becoming very established and we would rather hope that what happens in Germany, in terms of environmental things, will happen here perhaps a year or two or three later.

Chairman: Thank you. We have already moved into the territory covered by question 2.

Lord Porter of Luddenham

82. I am interested as to what the characteristics of hemp and flax are which makes these so suitable for these purposes. You have mentioned the strength. Does strength compare with terylene or nylon or indeed cotton? My second question is: are there any other products we do not know about, or we are not considering, apart from hemp and flax, in the same category for strong fibres and so on? There are a lot of other plants, weeds and so on, which seem to be in the market. Are flax and hemp way ahead in their suitability and competitiveness? Finally, just a quick one. You did not mention rope in the applications. I always think of hemp as rope. Certainly it was one of

Lord Porter of Luddenham *contd.*]

the main things which held the ships in harbour. Is that superseded by better things now?

(*Mr Hobson*) The rope industry has now turned to synthetics so it is not an industry that we would have targeted. We might have ended up with one or two orders for a tug of war rope but certainly for the shipping industry or the Navy it was not a proposition. Perhaps just a little bit of background on hemp: fibre hemp is one of the most ancient plants known to man. Records go back to 2500 BC on hemp fibre, particularly in China where it was used to make fishing nets. It is said that the great writings of Confucius were written on hemp paper. It has a very long history, particularly important here in the 15th and 16th century, when it made all the sails and rigging of the sailing fleet. The derivation of the word "canvas" is from "cannabis". But here we now have a fibre, the processing of which industry has lost, so we are trying to bring back what was an old fibre now into new markets. To answer some of your questions: hemp and flax are amongst the longest and strongest natural fibres available. Importantly, hemp and flax are the only fibres that we can grow here in Europe. The other fibres, jute, coir and sisal, could all be classed as tropical fibres so we cannot grow these here. Unfortunately, as you know, hemp and flax are subsidised by the European Union but so too are these other crops like coir, which will arrive on the shores at about £150 a tonne from Sri Lanka. That £150 per tonne is the cost of the transport and it is the Sri Lankan government subsidising coir in return for hard currency. So we are very much in a competitive market with these natural fibres. We would see natural fibres as complementary to synthetic fibres. We are not going to see the eradication overnight of synthetic fibres with the introduction of natural fibres. For example, in the automotive industry in Germany, the main bulk of the natural fibres used are used in combination with polypropylene fibre; that is, 50 per cent hemp or flax, and 50 per cent polypropylene fibre made into, as Nigel has explained, a non-woven mat or fleece. A non-woven is a fleece where the fibres are entangled. They are not woven. This fleece of 50 per cent hemp, 50 per cent polypropylene, is put into an oven where the polypropylene fibre, being a thermal plastic fibre, melts; and then it is cold pressed into a rigid panel. So there a natural fibre is complementary to synthetic fibres. In some cases the characteristics are better than that of synthetic fibres but in some cases not, so the word "complementary" would be good one where certain aspects work better.

Lord Birdwood

83. A quick follow-on question about other market potential. Has the market been explored for aircraft materials and for DIY, as a replacement of fibre board or even a substitute future for MDF, in appropriate circumstances?

(*Mr Hobson*) I will let Nigel answer some of that. Yes, some of those areas we have explored. Our organisation is a very small company. There are only three on the management team and we have, in running the factory, had very little time for R&D. So we have just tried to get it into the markets where we know we can sell it and get some money back in; then we can fund some future projects. We have spent quite a lot of time on entering the glass fibre replacement market, which could be used in the aircraft industry, automotive, etcetera. There are some technical problems to overcome but until there is some willingness from industry—from, say, the resin manufacturers, into which the natural fibre will form the strength within that resin—then we will not move this project on much further or very quickly. We do need help from industry. Some large industries—ICI has recently mentioned that it is going to put some R&D into its resins—in order to make their resins compatible with natural fibres rather than glass fibres. So we do want this investment and interest from industry. When research organisations turn round and say, "We are going to be five to ten years researching this," we have not got that long. We have to get going now. So let us get it into the markets we can get it into now, i.e. the automotive industry in Germany. I hope it will soon be here with companies like BMW owning Rover. I hope they will soon start to use natural fibres here. We do need further development of the paper industry. Just to go on to the paper industry. There is another section of the paper industry which can use natural fibres. We have had a lot of interest from environmentally conscious organisations that want to use non-wood fibres in the production of their printing and writing papers. We have just finished a project with the Bioregional Development Group in London to produce a local paper for London. That is where the paper has a 20 per cent hemp content and 80 per cent is made up of a post-consumer waste and is being sold, as I say, to these environmentally friendly organisations. This has been a great success. The first making is sold out and we are just on a second making. So this is another opportunity for natural fibres within the paper industry. Therefore, moving away from cigarettes into environmentally friendly printing and writing papers—

84. And packaging?

(*Mr Hobson*) And packaging as well. The problem lies in the production of the pulp. In the production chain there are very few mills in Europe which can take raw hemp and flax fibre and pulp it. They are all set up for wood fibres. There are only four mills in western Europe which are capable of pulping and only one in the United Kingdom. This is Robert Fletcher who are based at Oldham in Lancashire.

Lord Soulsby of Swaffham Prior

85. If I can go back to your introductory comments, I was fascinated to hear that one of the uses for the woody part is horse litter. What about other litter for other livestocks such as pigs and cattle and chickens in deep litter situations?

(*Mr Hobson*) We sell quite a bit of material, second grade materials into the poultry industry, for littering down broiler chickens and free range chickens. We have found, as a company, that the highest value product which we can get out of the hemp core, the pith, the centre of the stem, is the horse bedding, but there are other uses. It is used particularly in France for the renovation of very old buildings, where it is

Lord Soulsby of Swaffham Prior *contd.*]

used in the plaster, and has now been approved by the French Government in the renovation.

86. A bit like daubing.

(*Mr Hobson*) The hemp core, Shiv, is the technical term. The material can be petrified and turned into building blocks. It is a lightweight material. It is very good for both thermal and acoustic insulation. All of those markets are of a lower value than the horse bedding but the material is extremely good for that.

87. The other question: you said it is a large biomass but it needed no agrochemicals. I presume from that that it can be grown on all kinds of soil, including marginal soil where very few other crops would grow. Is that the case that it would grow almost anywhere?

(*Mr Hobson*) That is the case. Hemp prefers the lighter soils and we grow quite a bit up the east coast. Also, right into the Wales. It has even been grown on the sand dunes in Anglesey where no crop has ever grown before. It is a very drought tolerant crop. It grows so quickly. I make the analogy in talks that this is *Jack and the Hempstalk* and not *Jack and the Beanstalk* because of its phenomenal growth. But it is leafy. It produces such a leaf canopy to cover the ground, hence its need for no herbicide whatsoever. Its growth is so quick and its growing period between planting and harvest so short, that it is not suffering from any pests or diseases which would warrant a spray. Actually, getting into a crop that was ten or 15 feet tall, the spraying would be extremely difficult anyway. Farmers and growers really do enjoy a crop that they are not taking a sprayer into every five minutes.

Lord Rea

88. One question I wanted to ask regarding the use of both kinds of fibre for the aircraft and automotive industries. I did not hear you comment on its inflammability qualities. You mentioned that it has very low residue when it has been incinerated. You said "cremated". Is it possible to make it fireproof easily?

(*Mr Hobson*) It is with the use of chemicals. There is a company, which has just started up in the United Kingdom, which is looking at acetylating the fibre; that is, turning the fibre from hydroscopic to hydrophobic. It will also add in some fire retardant capabilities but where composites are to be used in planes or trains, where fire risk must be covered, then the chemicals can be used and certain resins can be used in encapsulating those fibres which are fire retardant. There is not a problem there but more R&D is needed certainly.

Chairman

89. Mr Bazeley, I do not want to let flax drop out of the conversation. Would you like to add anything?

(*Mr Bazeley*) What we have to keep reminding ourselves is that although both of these crops are steeped in history and have been grown for many thousands of years, the markets that we are actually identifying are relatively new. Just because we think these crops are better does not mean to say that we have a right to markets. Obviously any industry must be market led. I think the three things that perhaps I am continually reminded of is that unless there is a technical benefit for these fibres in a particular application, or unless there is a green story which ensures a market, or unless there is a price benefit, then they will not be used. The technical example is in the automotive industry, I do believe now that the use of many thousands of tonnes of flax fibre per year in automotives is not being done to be seen to be green and friendly. There are technical benefits. On the other hand, there is an insulation market; in Germany, for instance, where rock wool and fibre glass insulation is being replaced, to a small extent, by flax fibre. Where the sort of material that you would roll out in your roof to keep the heat in is being used. It is only a very small proportion of the market because it is at a significant premium to the competitor fibres and so it may be only 1 or 2 per cent of the German market which is actually using those products. However, that makes it significant to a small business which is operating in that market. I think that over the years we have come across a vast number of very interesting and potentially exciting markets for our fibre but it always comes back to these points: Is our fibre cheaper? Has it got a green story which is actually developing its market? Or is it technically superior to the competitor fibres? I think the major step that has yet to be made is in biocomposites. As John has mentioned, whether it is in boats or railways or aeroplanes, there is just a vast market, but there are technical difficulties yet to be overcome. There are people working hard at that.

Lord Nathan

90. It is very interesting in what you are saying about the use, which must be market led, to find an outlet. It would be very interesting to know what acreage is presently being cultivated and how many tonnes between one soil and another. Added to that, the question which I would like answering, is whether if you can extend the market into the fields to which you have both referred, whether there would be activity in increasing the acreage and tonnage to meet that requirement.

(*Mr Hobson*) If you remember, in 1993 we started with 1,500 acres. Last year we had 6,500 acres. We plan to plant between 6 and 8,000 this year. As far as the yield goes, average yield is around 2 tonnes of whole crop per acre. Our best growers are yielding between 3 and 3 and a half tonnes per acre of whole crop.

Chairman

91. So there is not much being grown this year to make an increase?

(*Mr Hobson*) We are more-or-less static this year. We will increase a bit, probably 1,500 acres increase, so maybe 6,500 to 8,000 acres, but we are having a few problems in attracting growers this year. Those problems I could cover. The first problem of getting growers with hemp is that it is subject to a Home Office licence scheme. Every grower has to pay a licence fee to the Home Office, this year of £300 per

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grower. The fee is irrespective of acreage. We started off in 1993 at £240 per grower and the Home Office wanted to double that fee to £480. In several meetings we have had with MAFF, the NFU and the Home Office, we managed to peg that increase to £320, which is what it will be next year, in the year 2000, but this year it is £300. That is the same licence fee as a company like SmithKline Beecham pays to the Home Office for the production of morphine, because the licence is for the production of a controlled drug. The nonsense is that hemp contains this negligible amount of drug. The problem is that its parent or species name is *cannabis sativa* which comes under the drug laws. We are the only country to have a licensing scheme. Hemp is now grown in large areas in France, Spain, Holland and Germany, and it has just started to be grown in Canada where it is thought that if they can grow large areas it can prevent some of the deforestation in Canada. But we are the only country to have a licensing scheme. That is the financial disadvantage it puts for the grower. Certainly it disadvantages the small grower, this £300 figure. Secondly, the Home Office dictate that you cannot grow hemp close to main roads, to housing areas, caravan sites, main footpaths, etcetera. That really does restrict the area where we can grow hemp. The restrictions have become a little easier since 1993, where the general public is becoming more aware of hemp. This is now just another agricultural crop. It is not some drugs factory or something growing out there. The problem is that hemp in the field botanically is identical to the smoking varieties of cannabis. You cannot tell the difference botanically in the field, so that does restrict our area. The other great problem is the level of subsidy that is paid on both hemp and flax, so the subsidy amounts are fairly similar. For example, last year, just prior to planting, Brussels was putting out messages that it was going to cut the subsidy by 25 per cent. In the end they did not cut the subsidy but we lost several growers who were not willing to take the risk of planting a crop that was suddenly going to have a quarter of the subsidy cut. This year there are also concerns that the subsidy is going to be brought down. If we could just talk about subsidy for a moment. This crop could stand alone without subsidies but not on its own. If other crops are subsidised, then if the subsidy was taken off hemp but kept on other crops, hemp could not survive. However, we realise that there is only one route for subsidies and that is downwards, and we thoroughly agree with that. We would like to grow hemp without the use of subsidies but, at the same time, there must be no subsidies on anything else. Do you want to ask Nigel on the yields?

92. Yes, perhaps that would be helpful.

(*Mr Bazeley*) As far as flax is concerned, in our first year we grew about 150 acres. We are now growing this year about 12,000 acres. As a country, where we started off with 100 per cent of the market, we have had one or two competitors come into it. This is mildly irritating but I suppose it is good for business generally. As far as the actual area of flax, I think we have seen a stabilisation at the present time. It is probably limited by three aspects. At the moment we are, in terms of getting growers, encouraging farmers to grow the crop. I think we are at about parity, in that we have to make the economics attractive to the farmer, relative to other crops. Increased developments on our processing side are helping to offset cuts in subsidy that we have had over the last four or five years. We have also an increase in regulation and in terms of access to subsidies this is becoming more and more difficult, more and more paper work, minimum yields, that sort of thing. I think also that our expansion of crops is limited by our processing capacity and the markets. At the moment, I would say we were roughly in equilibrium in that we have enough growers for the processing capacity in the United Kingdom for the markets, but I would like to think there was the scope to move this on. As far as yields are concerned, the yields of flax are lower than those of hemp. We would be looking at somewhere around 2 tonnes per hectare of crop production.

Lord Middleton

93. In 1990, when the Committee that Lord Selborne and I were serving on looked into the question of crops for non-food use and, in particular, flax and hemp, at that time hemp had not been heard of. In regard to flax, we were rather gloomy about its potential then because it appeared that alternative techniques to the rather primitive techniques that had always been used for retting flex were still under research. We have discovered that there is little or no investment in the necessary processing plant. We also took the view that improvements in genetic engineering could help some of the problems in producing and processing flax. So my question is directed to asking for an update as to what has happened in the nine years since. Is the process of extracting the fibre relatively more important than the variety of flax grown or hemp? Secondly, can new varieties, which have been developed since we last looked at this, produce high yields and improved fibres? Is genetic modification likely to play a significant role?

(*Mr Bazeley*) As far as the retting is concerned, for those who are not familiar with it, fibres are bonded to the outside of the stem by pectins; and retting is a natural process where bacteria break down these pectins, gums or glues to allow the release of the fibres. Traditionally, flax and hemp were retted by the crops being manhandled out of the ground and put into tanks of water, ponds or ditches to encourage this retting process. More recently, this has become unacceptable because of the effluent which is caused. Effectively, the demise of the flax crop in Northern Ireland was as a result of the fact that if one is not able to water ret the flax crop, because of the pollution problems, the alternative is to allow a natural retting in the field, "dew retting" it is called. This is fine if you happen to be in perhaps a coastal strip, where traditionally the flax has been grown in Belgium and Holland and Northern France. However, in Northern Ireland, where it is known to rain every day in summer, this has perhaps not been a very practical approach. Certainly there has been a reasonable amount of work looking at other methods of retting; in particular, the use of

Lord Middleton *contd.*]

enzymes. It may well be that ultimately an economic system of enzyme retting flax and hemp will be developed and will be commercialised. But the problem I see with that, is that to use enzymes means immersing the crop in water, water plus enzymes. Then the crop needs to be dried again. The amount of energy involved in this process to still produce a fibre which has to be competitive with other natural fibres as a feedstock for industry is difficult. The alternative is to stay with the natural system of dew retting in the field. At the moment, I think this is the most realistic way to handle the crop, provided that one has a range of markets. There is a variability of crop as a result of natural dew retting in the field, where the straw is left in a swath for an amount of time to allow this action to go on and then for the crop to be baled and taken to the processing plant, because of the vagaries of weather and season. Tere are bound to be differences in the degree of retting that each farmer actually produces. Our problem can be that, with 400 farmers growing a crop, we have 400 different specifications of fibre produced. Whilst we have a range of markets, we can live with that. Whilst we have the paper market which is a relatively low specification level and we have some non-woven markets and also some opportunities to get into some of the textile markets, then we have a system which is acceptable and operational. The idea of having an artificial retting system, where we can dictate accurately the degree of retting and therefore the quality or characteristics of the fibre that are released, is super. I just have my doubts about the economics. As far as processing systems are concerned, our company's involvement in the flax crop is borne entirely out of involvement in a research and development project earlier in this decade. There was the development of a new processing system. I do not want to bore you with too many details but to my mind it is the way that research and development should go. A chap in Scotland had an idea that, by using pins—and this company makes pins for the textile industry—you could develop a machine to extract an industrial grade fibre economically from linseed or flax. He got in touch by a circuitous route with the Silsoe Research Institute in Bedfordshire, which is involved in agricultural engineering research and Silsoe managed to persuade the Ministry of Agriculture to fund a three year project to investigate the principle of using stripping pins. That proved successful. That then led on to a three year Link Crops for Industrial Use project, which was the biggest Link project ever approved. We were one of ten partners, five academics and five commercial companies, to develop this principle of using pin technology to extract fibre. The project was called Fibrelin and we operate a Fibrelin processing machine now. Having succeeded with this Link project, we have taken that into the commercial world and have struggled to make the thing commercial. There have been other developments. In our search for machines, we have trawled if not the world certainly Europe for new developments, new technology and new systems for extracting and cleaning fibres. There is plenty of machinery out there. The difficulty is to find a machine or a system which is economic. In particular, there is one French company and two German companies which have developed super technology brought from the textile industry and they have the most fantastic systems. You put some pretty ropy looking flax straw in one end and out the other end comes this superb, clean, lovely fibre. The problem is that the yield is so low and the cost of the machinery is so high that it is not viable. There have been several of these systems put in throughout Europe, none of which to my knowledge at the moment is currently working economically. The key has been to find a system which is relatively low cost, relatively high throughput and produces a quality of fibre which is targeted at perhaps a modest range of markets and not too refined a market.

94. I think the second part of my question is how far plant breeding is going to alleviate some of the problems.

(*Mr Bazeley*) As far as flax is concerned relative to the retting and processing it is a relatively minor issue, I think. Any development in plant breeding would help the grower to produce a package which works. For us on flax there are two areas which are of interest. At the moment, all our varieties are spring sown. There are breeders who are working on winter sown varieties. The attraction for us would be that instead of having our harvest at the end of August/beginning of September, which then results in us having to leave the straw in the field for one to three weeks to allow the retting process, if we were able to harvest the crops in the middle to the end of July and then have the retting period through August, I think it would reduce the risk of crops being lost or over-retted. That would be and will be a major step forward. The other would be to increase the seed yield. For linseed, we have relatively short varieties with high seed yields and, for flax, we have relatively tall varieties with low seed yields, but high yields of fibre. Dual purpose varieties potentially will improve the financial return to the farmer and then allow the crop to be economic, despite future reductions in subsidy. Everything that we are trying to do, whether it be to develop the farm systems or the processing systems or the markets, we have to remain focused on the fact that if we do not actually achieve some headway in these directions we will have a crop which is not viable without subsidy.

(*Mr Hobson*) We are fine with the dew retting process. All our hemp is left on the field for probably three to four weeks to undergo this dew retting process. We have just developed new harvest technology which uses a maize forage harvester, which cuts the stems—remember, this crop is 10 or 15 feet tall—into foot or 18 inch lengths. That means that it undergoes the retting process more quickly on the field and the crop bales more easily and ultimately processes more easily. The first thing we do in our factory is cut the stems into these lengths anyway, so it saves a factory operation. We have developed a very successful factory operation for the separation of these two main fractions, the fibre and the woody core. That works well with a fairly low labour requirement. That is all okay. The plant breeding of hemp at the moment is in the dark ages. We are working with some very old varieties. However, new varieties are coming forward. Importantly, there are some zero THC varieties coming forward. We hope

Lord Middleton *contd.*]

this might be a way forward with the Home Office. If we can produce a variety of cannabis that has no THC, do we then have to have a licensing scheme? There is huge scope for plant breeding. I believe that this can be done with conventional plant breeding and it is not necessary to bring in genetic modification. That would be the wrong thing to do now, to tarnish the image of hemp as a very environmentally friendly crop and suddenly say, "We have these varieties coming forward but they have been genetically modified". That would not be a good move and would damage an infant industry.

95. Am I right in thinking that there is only one processing plant for hemp at the moment which would thereby restrict the growing around that area?

(*Mr Hobson*) Yes. We are the only grower and processor in the United Kingdom but we are to be joined next year, we believe, by another company. No one else has felt willing to take the risk so far.

Lord Soulsby of Swaffham Prior

96. If one could broaden this out a little bit not only to flax and hemp but to other non-food crops and regulations, both in this country, of which you have mentioned some, and European Union regulations. Do they, on the one hand, restrict or, on the other hand, encourage the development of non-food crops in this country?

(*Mr Hobson*) There has been quite a large subsidy available on both flax and hemp. That has led unfortunately to some fraudulent growing around the Community, or growing just to gain the subsidy without the crop ever being processed. I can only speak for Hemp. Nigel can talk about flax but, for hemp here, the Home Office licence scheme does not allow any fraudulent growing because the Home Office dictates that you must grow the crop for a certain purpose—i.e., it is going to go to a company like ourselves, a registered processor. You cannot just grow it because you like the look of it. For example, last year, 21,000 hectares were planted in Spain with hardly any processing whatsoever. Those farmers gained the subsidy; they grew the crop, harvested it and were paid the subsidy but nothing has happened to that produce. In some areas of Spain, we believe, the hemp subsidy was equivalent to the land value so in one year those farmers had bought the land with the hemp subsidy. However, this year, the European Union have put in new rules now and you can only grow hemp in the Community if you have a contract with a registered processor. You will only get your subsidy after the crop is processed. There is a minimum yield and a minimum sowing rate. That ought to cut out this bogus growing, depending on the way those rules are implemented, of course, in other countries. Certainly in the United Kingdom the rules are implemented to the letter of the law and there will be no fraudulent growing here. We would like the crops to be free from subsidy and free from all these rules. The subsidy is vital now and it is vital that that subsidy continues for the next few years, (a), whilst other crops are still being subsidised, because if we took the subsidy off hemp and kept it on the others we would not have a business; it would be lights out for natural fibres; and, (b), it is vital that the subsidy continues until these very infant companies like Robin Appel, British Fibre and Hemcore have developed the markets for the products. Those markets are not yet developed.

97. I would like to come back on the United Kingdom licensing situation. You mentioned exportation of hemp fibre and woody fibre. Is there any movement into this country from the European Union or elsewhere in the world, with the relatively small amount of acreage that is planted?

(*Mr Hobson*) The acreage is quite large on the continent, although still relatively small here in the United Kingdom. There is both French fibre and French horse bedding pouring into the United Kingdom. We are competing with this paper company in Oldham against French fibre. Things like this extra licensing scheme are putting British farmers at a disadvantage against continental growers.

98. If that licence had to be reduced or abolished, you would be in a much better position to compete?

(*Mr Hobson*) Yes, we would. We are further disadvantaged by the strength of the pound at the moment in exporting. Most of our fibres go to Germany and yet the strong pound is good for the French hemp and horse bedding coming in here so it is helping them. Plus they have not a licensing scheme.

Lord Nathan

99. You referred to being a registered producer and you referred to others as being registered producers. Registered with whom and what is the qualification for registration? What is the point?

(*Mr Hobson*) Registration with the Intervention Board who pay out subsidies.

100. That applies to the producer, being the farmer or being the manufacturer of the product?

(*Mr Hobson*) The producer is the farmer. We, Hemcore, are the processors.

101. The processor does not have to be registered?

(*Mr Hobson*) The processor has to be registered.

102. Why?

(*Mr Hobson*) So that we can prove to the Intervention Board that we can process a grower's crop and we can turn it into something useful; that we are bringing in raw material and we have products going out of the door. They have to be convinced that we have a market and we are not weighing it all on a weighbridge, taking it round the back door and burning it all.

Lord Rea

103. You say that there is absolutely no botanically detectable difference between the cannabis sativa that has a very low THC content and that which has quite a high THC content. I can see that this would be a wonderful opportunity for somebody to grow the high THC product somewhere perhaps on the edge of or in the middle of an industrial crop of hemp. Does this present a policing problem, one,

Lord Rea *contd.*]

and, two, you said it was a £320, one off, per annum licence per grower. Therefore, if you had a very big acreage, it would not matter so much in proportion to the product and therefore it will deter small growers. Can you expand a little on those themes?

(*Mr Hobson*) I suppose our average area is going to be somewhere around 30 acres or so. We have some large growers. You are quite right that it is an advantage to them to have a licence fee that is irrespective of acreage, but we are very conscious that it does disadvantage the small grower. Turning to the licensing scheme and this concern about growing high THC material, if somebody wanted to produce high THC plants they could not do that very well outside. I do not know a lot about the subject but THC needs intense heat and light and that will be possible probably in more southerly climes than here. It would not really be possible within the United Kingdom to grow high THC hemp within crop. The THC would be of an extremely low yield. I do not think people would be willing to take the risk of planting outside, in the countryside. We do not really see that as a main risk and I do not think the Home Office would see that as a main risk, if you asked them. The Home Office are more worried about the nuisance value of this, of children and what have you going and picking leaves and that sort of thing, and the crops being infiltrated.

104. Do they do any checks and sampling?

(*Mr Hobson*) Yes. The Home Office licensing scheme requires a Home Office inspector to go to the growing site, first of all, to gauge its proximity to main roads, housing etc. Remembering that these inspectors are more used to inspecting dispensing chemists and looking at padlocks and things, they are a little at sea when they are out in the countryside. They also ask the grower whether he has a drugs conviction and the grower will be licensed, but he has to record where those fields are being grown. The local police are informed where those fields are.

105. Does the Home Office arrange for samples to be taken and analysed for THC content?

(*Mr Hobson*) In the early years, THC samples were taken. That responsibility now falls upon the Intervention Board who have to take samples because the varieties must not go over 0.3 per cent. We are growing varieties that are guaranteed to be under 0.3 per cent. In all of the testing, we have never had a crop greater than 0.1 per cent.

Earl of Selborne

106. We are talking here about hemp and flax, which are your two areas of expertise. You have explained that these are the two sources of plant fibre for which we have a natural advantage in northern Europe, but we understand that MAFF are conducting a programme of research on a number of alternative sources of plant fibre, nettles, miscanthus and the like. Are you aware of these programmes and do you feel that any of these are likely to prove runners?

(*Mr Bazeley*) We are aware of MAFF funded projects. As far as I am aware, that particular project has finished. The conclusion is that hemp and flax are the only crops which currently show opportunities for commercial production in the United Kingdom. That is not to say that other plant species will not at some stage have opportunities. As well as looking at flax, we have actually grown hemp a few years ago to see what opportunities there were for us on a commercial basis. We are also investigating other species ourselves. In business, we need to take the line of most likely success. That does not even mean that it is going to be a success, but because we know that flax and hemp have been cultivated in the United Kingdom for thousands of years they are the obvious ones for us to start with. I would like to think that we could move on to others in the future but at the moment we are not doing that.

107. Nettles have been grown for thousands of years. We seem to have a natural advantage.

(*Mr Bazeley*) That is a species that we are looking at. There has been quite a lot of development work in Germany to produce nettle varieties which could be suitable for production here, one of the attractions of course being that you do not have to sow them every year. They are a perennial crop.

108. I agree it might be somewhat difficult to persuade farmers to grow them for you. Going back to the availability of grower contracts for flax, as opposed to hemp where clearly we have these licensing difficulties, what are the constraints in getting growers to sign up to contracts for flax?

(*Mr Bazeley*) As hemp has this drug connection and flax does not, there is no involvement with the Home Office at all. As far as flax growers are concerned, it is a straightforward contract between a farmer and ourselves to grow the crop. The only complication really—and it is a double edged sword—is the subsidy arrangements, which are complicated, to say the very least. To that end, we are a registered processor. We have to be registered with the Intervention Board. We are audited monthly, where we have an Intervention Board inspector come out and check our weighbridge tickets and our processing systems, our sales and our purchases. This action is releasing subsidies for farmers. The only other relatively minor point is that, as an industry, we got together a couple of years ago. There were some problems with some old pastures being ploughed up to grow flax. The flax and hemp support scheme is outside the mainstream subsidy system and therefore flax and hemp can be grown on ground which is ineligible for other arable subsidies. This is both an advantage and a disadvantage. The advantage is that for us, as companies trying to place contracts with farmers, provided the economics of flax or hemp compare favourably against livestock enterprises for instance, we have access to growers and the growers will be forthcoming. One problem that arose that I know the Department of the Environment got quite steamed up about was that of one or two well publicised cases of farmers ploughing up Sites of Special Scientific Interest to plant flax. We are trying to sell a fibre based on its environmental credentials, so the last thing we want is a farmer to plough up land which otherwise would be considered to be environmentally sensitive. The various contractors of flax got together and we have a protocol now which we have all agreed to and that every farmer agrees to, to ensure that not just Sites of Special

Earl of Selborne *contd.*]

Scientific Interest but other land which is considered environmentally sensitive—in particular, old grasslands—is not ploughed up in favour of flax.

109. Do I understand you therefore to say that because it is outside the arable aid schemes farmers are unlikely to plant it on IACS registered land?

(*Mr Bazeley*) That depends entirely on the economics. Three years ago the majority of our flax crop was grown on land eligible for mainstream subsidies. Now, the vast majority is not; it is on ineligible land. That is because the relative economics of flax against the other arable crops have slipped a bit. I think it is quite conceivable, with the Agenda 2000 agreement, that we will see flax, and possibly hemp, come back onto the more mainstream land which I think would probably be an advantage for us because to some extent—and it is a generalisation—those farmers are more professional, arable farmers than perhaps some of the farmers who have been growing flax and hemp who have been more livestock orientated. Flax can be grown and hemp can be grown on ineligible or eligible land and it will depend entirely on the economics as to where and how much will be grown.

Lord Soulsby of Swaffham Prior

110. You have partially answered this question but were there to be no subsidies for food crops and non-food crops, could the non-food crops compete effectively and economically?

(*Mr Hobson*) Yes, they could. Just to recap on that, we want the subsidy on hemp to continue for the time being while we are at these very infant stages of setting up the markets for natural fibres. We can then survive in the future with no subsidies at all, as long as there are not subsidies on other competitive crops, other crops that are going to be sown at the same time, beans, linseed or whatever.

Chairman

111. Food crops as well?

(*Mr Hobson*) Both food and others. For example, if they took the subsidy off hemp and kept it on flax, we would not have any area at all in the United Kingdom. Everyone would grow flax. That would be a problem, but we would like to see subsidies come off all crops and then we would not be saddled with all these hoops that we have to go through to get the crops grown.

Lord Soulsby of Swaffham Prior

112. As a corollary to that, are there other sources of similar fibres that might be developed in this country and eventually become economically viable?

(*Mr Hobson*) We touched on nettles and miscanthus. As Nigel said, we have concentrated on those fibres we believe there is a market for right now. Others might come through but mainstream hemp and flax both grow extremely successfully in these temperate climes and they will form the main bulk.

113. Your main competitors are other growers, either in this country or in the European Union?

(*Mr Hobson*) For hemp, our competitors are flax and tropical fibres, jute, coir, sisal. The advantage we have in the market place, like the German automotive industry, is where that automotive component maker feels he has reliability and continuity of supply with both hemp and flax; whereas, with some of the tropical fibres, if there was a flood or something in Bangladesh, then there is going to be a shortage of jute in one year. You can rely more on those fibres that are now indigenous.

Lord Middleton

114. Mr Bazeley did mention Agenda 2000 and its effect on production. Can he say what has come out of the Berlin Summit, where we are told agreement has been made on various aspects of Agenda 2000, and its effect on his industry and on farmers?

(*Mr Bazeley*) The effect on our company is quite profound with regard to linseed, which I know is perhaps not the issue here, but we have been involved with the linseed crop. As you know, it is the largest non-food crop grown in the United Kingdom. We have been quite frustrated by the whole Agenda 2000 procedure in that not only our company but plant breeders and various people in the processing chain have been investing and developing in the linseed industry for many years now. Because the United Kingdom is the main producer of linseed in Europe, we felt that there were opportunities. It seems to suit our climate; it is a useful cropping option for our farmers. What was proposed under Agenda 2000 was that the linseed subsidy would be reduced to the same level as that for cereals and set-aside. That has happened although it is being phased in over three years. Our frustration on that issue was simply that we felt that there was a United Kingdom advantage and perhaps it would be rather nice if the United Kingdom were to defend that position and try and argue for some stay of execution, if you like. The fact of the matter is it has been agreed. A cut in the linseed subsidy is being phased in over three years, as most of the cuts are. Perhaps the most significant effect that will have on the fibre crops is that, all other things being equal, fibre crops may move back on to eligible land because if the aid rates on other arable crops are reducing and if flax and hemp are to remain the same for a year or two or three, then they become more attractive in comparison. We have been told that there is due to be a reform of the flax and hemp regime later this year anyway. I am sure there are many other issues here other than subsidies and support, but there is one point I would like to make. Subsidy schemes are a double edged sword. On one hand, they allow us to operate and, on the other hand, they are hanging over us. As commercial businesses, we know that with a flick of the pen in Brussels we do not have any growers. For the size of our company, we have a large amount of money invested in machinery. We have just installed another £150,000-worth of machinery. I have to convince my fellow directors that this is a wise and positive move, but it is really a jump in the dark. The serious issue here is the development of these crops. We have both indicated that there are significant market opportunities that we see developing in the next few

Lord Middleton *contd.*]

years. What has not been a barrier until now, but what is likely to be a barrier in the future is investment by commercial companies into these crops, because of the risk and the uncertainties of support. If there were a structure where we even knew what was going to happen in the next three to five years in terms of phasing out of subsidies, that would be better than not knowing at all. Both of these crops are relatively strongly supported and at the moment relatively dependent on that. As John has pointed out, we would like to think that the support scheme at the moment is critical for the development of these crops to allow farmers the time to gain the experience of growing and retting crops, for us to have the time to fine tune and develop the processing systems but also to allow the markets to develop. At the moment, they are absolutely essential. This barrier which will develop will be the investment risk because of the uncertainties in the scheme.

Lord Birdwood

115. Can I ask two tiny technical questions? The first is would flash freezing degrade the bond between the fibre and core as a substitute for water retting?

(*Mr Bazeley*) I have absolutely no idea. I know that there are other methods. In particular, I know that sonics have been used. There has been some developmental work in that area. Steam explosion has been used, again in Germany where all the development work has been done. Both of these systems have proved a system but have failed to prove a viable economic system, as far as I understand.

116. Going back to potential applications, is there a formulation of the finished product that is oleophylic and hydrophobic at the same time as, for instance, in oil spill reclamation plans?

(*Mr Hobson*) Fibres have been used for oil spills.

117. I know that jute already has a potential.

(*Mr Hobson*) Hemp and flax fibre would have great potential—unfortunately, fairly low value but they do have great potential for absorbing oil. That material would not be acetylate. It would not be termed hydrophobic first. Hydroscopic fibres would be used. Turning very briefly to your question about flash freezing, just talking about hemp now, the dew retting we feel is sufficient for the separation of these fibres to a certain level, but if we want to gain higher value for fibres, say, to get hemp fibres into the apparel industry then something else will have to be used such as ultrasonics or steam explosion. That is where pure fibre would be put in so the economics would stack up very much greater, rather than just using these very expensive processes for pure decortication, so put it through a very simple process of decortication first and then for higher, added value, user perhaps these processes.

118. I would like to ask whether there are any particular environmental or ecological advantages or disadvantages, or certainly perceived disadvantages, from growing either of these two products.

(*Mr Bazeley*) On the flax front, I do not perceive any disadvantages but I do have a rather large axe to grind here. We use some agrochemicals on the flax crop but at a lower level than most other arable crops. As far as the growing of the crop is concerned, I suggest we are slightly on the environmental side, but the main issue is the markets. We do perceive the real potential to be to displace some of the glass fibres, the asbestos and the synthetics and to produce a renewable, sustainable, biodegradable product. The environmental issue is absolutely critical to the large scale development of these markets. That is not to say that there would not be technical markets, but I do think this is a fundamental part of our future.

(*Mr Hobson*) Just to sum up the benefits of hemp for the environment, to look at first of all the grower or the producer, hemp is a vital alternative crop. It is a late spring sown crop, late April/early May, so this spreads the workload for the grower. Apart from the seed cost which at the moment is quite high, there is a very low cost of growing. No agrochemicals are put onto this crop and the farmer actually enjoys that. It is a true break crop and has an important role in the farmers' rotation. It leads into an ideal entry for cereals. Growers have reported their best yields coming from cereals following hemp, in that it has structured the soil and the leaves that have senesced prior to harvest do leave some valuable residual fertilizer. It encourages wildlife. It is a very good cover crop and the seeds that are left on the ground encourage game birds. It leads to a profitable return for the grower. To move on to industry, natural fibres can lead to new employment for factory staff. The fibres sent on for further processing will benefit other industries in the production chain. This is now particularly important for Britain's textiles in both the apparel and industrial industries that are suffering at the moment. There are health advantages for workers within these industries in working with natural fibres, these workers that are working with glass fibres and mineral wool. It is much more friendly for them to work with natural fibres. We have discussed the advantages for industries with the particular aspects of natural fibres in the automotive industry, lightweight etc. At the moment, most of our fibre is going abroad and that is helping our exports and ultimately the balance of payments, although in a very small way at the moment. To sum up on the environment, natural fibres are helping to break up the cereal monoculture. With hemp, no chemicals; wildlife benefit; these crops are absorbing large amounts of CO_2 from the atmosphere. Hemp has been used in some eastern European countries to absorb heavy metal pollution from the soil. It is particularly good at absorbing things like cadmium. What you do with the hemp after it has absorbed the cadmium is a question but it has been used in some areas where eastern European factories have been putting their waste outside the back door. Hemp is particularly good at absorbing that pollution. The whole crop is processed. Our factory operates on a zero waste policy. Finally, all natural fibres are biodegradable. We have an opportunity here to stop filling up holes in the ground if we turn to biodegradable fibres.

Chairman

119. Thank you very much indeed for spending so much time with us and taking the time out of what I realise is a very busy management of both your

Chairman *contd.*]

businesses. We do appreciate it. It is very important to hear from those who are really involved in these applications. If there is anything else you would like to say at this stage, please do. Otherwise, if there is anything you think of later and you would like to send to the Committee in the course of our inquiry, we would be very interested to receive it.

(*Mr Hobson*) Would you like a written submission, summing up points?

120. Anything that you would like to follow up with. There has been a full record taken so do not feel there is any need to repeat but if there are any further points you would like to put to the Committee or questions we would be very grateful for that.

(*Mr Hobson*) Thank you for the opportunity.

TUESDAY 20 APRIL 1999

Present:

Birdwood, L.
Hogg, B. (Chairman)
Mackie of Benshie, L.
Marlesford, L.
Middleton, L.
Nathan, L.
Porter of Luddenham, L.
Rea, L.
Selborne, E.
Soulsby of Swaffham Prior, L.

Examination of Witnesses

PROFESSOR DAVID WHITE, Director, Science and Technology, DR DOUG YARROW, Director, Business Innovation and International Group, Biotechnology and Biological Sciences Research Council, PROFESSOR ALISON SMITH, Research Scientist, the John Innes Centre, and PROFESSOR DENIS MURPHY, Research Scientist, the John Innes Centre, called in and examined.

Chairman

121. Good morning, Professor. Thank you for coming to give evidence to us at what I know is relatively short notice. Perhaps you would be good enough to introduce yourself and your colleagues. We do of course have your evidence, but if you would like to say a few words by way of introduction, please feel free to do so.

(*Professor White*) Thank you, Chairman. My name is David White and I am Director of Science and Technology at BBSRC. I am on a four-year secondment from the University of York where I was Head of Biology at the time I left, now one and a half years into my post with BBSRC. I will next introduce Dr Yarrow.

(*Dr Yarrow*) I am Doug Yarrow. I am Director of Business Innovation International at BBSRC, responsible for the job on linking our science base with industry and also our international programmes.

(*Professor Smith*) I am Alison Smith. I work at the John Innes Centre in Norwich which is one of the BBSRC funded research institutes. I specialise in the analysis of starch and I am here to provide scientific backup on whatever David White may have to say to you.

(*Professor Murphy*) I am Denis Murphy. I am also at the John Innes Centre in Norwich. I am Head of the Brassica and Oilseeds Research Department and am a specialist in oilseed crops. My expertise is in oil and vegetable oil areas.

122. Thank you very much indeed. Professor White, is there anything you would like to say by way of introduction, or otherwise could I take you on to the first question which is to say a little more to us about the main objective of non-food crop research which you fund, and indicate how you think those objectives are likely to change over the next decade.

(*Professor White*) We support non-food research in BBSRC by a number of mechanisms. We have as starters a lot of fundamental research into all parts of biology and that is not specifically for non-food research. I can tell you a little bit about that if you would like me to. That underpins non-food research, amongst other things, because it deals with the basic mechanisms of biology and so feeds upwards into the non-food research. As far as specific issues for non-food research are concerned, we have a number of mechanisms within the Research Council for putting money in particular directions. One of those is LINK programmes with industry and in 1990 a LINK programme was set up called *Crops for Industrial Use (CIU)* and that ran for five years. That funded a particular set of projects. We also have within our response-mode funding what we call research programmes which are strategic programmes aimed at taking the fundamental research to the next stage on. Partly as a result of the *Crops for Industrial Use* LINK initiative, we set up a research programme called *Wealth Creating Products of Plants,* which is an ongoing research programme aimed to take the fundamental research one stage further. More recently we have set up another LINK programme, which has other partners (MAFF, EPSRC) as well, called *Competitive Industrial Materials from Non-Food Crops*. That has only recently been started and that if you like takes the crops for industrial use line to the next stage. The way that we see this going in the next decade is that we wish to see how the *Competitive Industrial Materials from Non-Food Crops* goes. I would say that the research which has been most developed has been on the whole the large volume crops. I suspect in the next decade we will see more of the high value crops coming to the fore which are not well developed at the moment. That would be the trend that I would see over the next 10 years.

Lord Williamson of Horton

123. First I should declare that I have spent quite a lot of my life working for the Ministry of Agriculture. Indeed I was Head of the branch that deals with agricultural research in pre-history times. I was also Deputy Director-General for Agriculture in the European Commission for quite a time. I do not think that biases me too much as a matter of fact. In your evidence you have made quite a number of statements in rather general terms, if I may say so, such as that there are further opportunities for the use of high erucic rape or that non-food products such as starch have the potential to be economically successful and that fibre crops will be significant in

Lord Williamson of Horton *contd.*]

the long term. There are quite a lot of general phrases like that. May I just ask you to take a risk and indicate where you think the most promising developments are because we have a very wide range of developments and from the point of this Committee it would be helpful to get some idea of where more specifically the most promising developments are likely to come.

(*Professor White*) We have brought with us somebody who is an expert in oils and someone who is an expert in starch, which are two of the products you mention. If I may I would like to ask them to take the lead in answering that.

(*Professor Smith*) Obviously I am going to be biased towards the excitement of the science in my own area of starch. As I am sure you know, starch is enormously valuable as a raw material for industry, not only for things for which starch is always used as an additive to paper and to particular types of food, but also in replacing petrochemicals. At the moment we have bulk starches from relatively few crops but we know that we have the potential to modify those starches, to change their functionalities and to produce things which industry will find more useful than existing starches. At the moment industry chemically modifies the starch that it obtains to change its properties in order to make it suitable for particular uses. We know that we can create in plants both through conventional breeding and through genetic modification quite novel types of starch which will not require those expensive and polluting modifications. Indeed, one of the non-food crops created by genetic modification that is closest to getting full approval in Europe is a modified potato starch which has enormous potential particularly at the moment in the textiles industry. That is one example of something very useful. I am sure Denis Murphy will talk about oils but I should just say that I think the potential for things like vaccines and other types of pharmaceuticals is also enormous and is a very important area in which there could be further developments, although it is not really my field.

(*Professor Murphy*) High volume oils tend to be of low value but there are many uses for non-food oils. The main problem is the purity of the oil, i.e., to get high levels of a particular oil that you want with a particular fatty acid. That is an emerging area of science at the moment. A company in America, DuPont, have developed a high oleic acid rape seed which can be used as a clean source of lubricating fluids. High erucic you mentioned. The problem about that is that the erucic is mixed up with other components. If we get pure erucic acid we can increase enormously the amount of uses that we can make of that oil. Again that is an ongoing area of research in my own Department. Another area is high value products which are made in smaller amounts. We and others are looking at using oils as carriers for high value proteins like pharmaceuticals and so on. These are all emerging areas. It is difficult to identify products which are on the market now. We are still looking five to 10 years in the future before these will be around.

Lord Middleton

124. Professor White mentioned high value products. In the paper at paragraph 11 it says: "The high value products are likely to prove most significant economically since they can be produced in small areas ..." Farmers at the moment, faced with the situation we have of reform of the common agricultural policy and the need to work on world margins, think that the most significant economic products will be those which can be grown on large areas. Does this tie up with the research on wheat and is there any prospect of the wheat products being greater than one per cent of the total which I see is also mentioned?

(*Professor Smith*) I am afraid the agricultural end of things is not really my area of expertise. One of the problems with the bulk chemicals at the minute (and Denis Murphy is more of an expert than I am) is that many of them are competing with oil-based products in the non-food area. Oil is extremely cheap at the moment. The value of these crop derived products is not high enough to allow them to compete with oil. On a bulk level those are not particularly valuable products. Although the materials are good, their price is the problem. This is an economic problem rather than a problem with the materials themselves.

Lord Nathan

125. We have heard this morning and previously about cheap mineral oil and the difficulties that presents so far as substitutes are concerned. The price has gone up over 50 per cent in the last few weeks. Can you give us any indication as to the price of mineral oil which would make your products viable because at the moment we are completely at sea? Would it be $15 as it presently is, $20, $30? What is it we are talking about?

(*Professor White*) I do not think, Chairman, that we are competent to answer that question, I very much regret. I am prepared to ask my colleagues but on that sort of issue we do not have a good idea and it would be wrong of me to pretend otherwise.

(*Professor Murphy*) Diesel oil from petroleum costs about $200 per tonne at the pump. The kind of oils we produce cost about $600 to $700 per tonne, so one needs at least a factor of three increase in the price of mineral derived oil to get anywhere near what the vegetable oils cost. This example is for biodiesel, which is the cheapest oil.

126. That is extremely helpful because it indicates that you are miles away from being viable.

(*Professor Murphy*) That is to use it as a fuel when one is just burning it. Obviously that is the lowest value. If one uses it as a lubricating fluid the value is different.

127. Can you give us any guidance on that?

(*Professor Murphy*) I think we are talking about double, not four times, i.e., at a world oil price of $30-40 per barrel, vegetable oil based lubricants may well be competitive with petroleum based lubricants.

(*Dr Yarrow*) If I could comment on plastics produced through oil, I think the conventional price for producing plastics from petrochemical feedstock is something like 20p a kilogram. If Zeneca ICI are

Lord Nathan *contd.*]

producing the by-products by microbial fermentation I think they are priced at about £10 per kilogram at this moment. By looking to move that into plants, they are looking to bring the price down to of the order of a pound a kilogram, a fairly significant reduction, to produce it in the field, but yet not at the price levels for plastics which are produced conventionally, although plastic produced by that route would have other benefits such as environmental benefits.

Lord Birdwood

128. To a certain extent, Professor White has answered a lot of questions on this paper. I was going to home in on the economics. Have you developed a replicable financial model in this particular area of expertise that you can display to people? Before answering, I was wondering whether you had developed or made any effort to develop relationships with sources of capital, because your customers, companies, however enthusiastic, need to persuade both internal and external sources of venture capital that what they are proposing to do will make money. It seems to me that you could be much further up the food chain in terms of going in to bat with your customers with evidence that indicates that what they do next has economic viability.

(*Dr Yarrow*) I think that in terms of launching new businesses on this technology the venture capitalists often feel more comfortable investing in areas where they can see quicker returns and significant returns. Therefore, to my knowledge, most of the interest has been in the pharmaceutical end where of course we have seen access to genetics there leading to these vaccines within plants bringing in external funding. Indeed Zeneca have been investigating with the Institute of Grasslands and Environmental Research plant derived products. It is much more difficult to bring in external funding for new ventures when you are talking about these more medium value things, and perhaps the route of exploitation there is more through large and already well developed companies.

(*Professor Smith*) I wonder if I could change this slightly to say that economics is certainly not the only consideration which promotes companies to use these materials. I am aware that major paint manufacturers for example will push up the price of paint in order to make a greener product by using starch to replace petrochemicals. I was tempted to bring today some packaging granules made of extruded straw. They look like those dreadful polystyrene packaging granules that wash up along the south coast, but they are soluble and they can be biodegraded by organisms in the soil. They are at least as functional as existing polystyrene based packaging materials. They are marginally more expensive because starch is more expensive than petrochemicals, but there are a number of companies which are using those because they see that the customer wants those greener materials. It does not want the south coast covered in polystyrene. There are strong social implications for using these materials, not simply economic indications, and some companies have recognised that the slightly higher price for the time being may actually be worth it, that customers will buy these things if they can present them in the correct way.

Lord Nathan

129. I am sorry to press the point again, but can you tell us what you are talking about, "a slightly higher price"? Are we talking about a penny a pound or are we talking about hundreds of thousands?

(*Professor Smith*) I am sorry, I do not know with the packaging granules. I think they are probably twice as expensive as existing ones but I really do not have the facts. One of the world's leading starch companies manufactures these things on an enormous scale and it is economical viable for them to do it. Even though they cost more, people are buying them because they are biodegradable.

Lord Soulsby of Swaffham Prior

130. In the documentation you provided on the Council's mission you say it is: "to promote and support high quality basic, strategic and applied research". When a project is being considered by the BBSRC for funding, and assuming that the science of various proposals is equal, how does economic potential weigh against its significance for the advancement of science? Is there a scoring mechanism that you use to differentiate the two?

(*Professor White*) It is a slightly different answer depending upon whether it is a pure response-mode grant coming into a committee or whether it is going to a LINK programme. We pay greater attention to the economics with the LINK programme than we do to the basic research coming into the committees that fund response-mode grants. We score an application with a single score and we ask the committee to score using a set of criteria which are including scientific excellence, strategic relevance (which includes the economic factor), prosperity and quality of life, timliness and promise, and cost effectiveness. The individual members of the committee are then required to weigh those together in order to come up with a single score, so we do not take a particular weighting for those different criteria. The strategic relevance in particular would have a greater relevance when it comes to the LINK programmes where the way of funding is slightly different.

131. Is there any demarcation or division of effort between food and non-food crops in terms of research? Is it all considered by one research committee or are there two groups?

(*Professor White*) We have seven committees. None of those distinguishes between food or non-food within their remit. If we take, for example, one of the committees, Plant and Microbial Sciences, they will take in plants that have both food and non-food grants in the same meeting and they will consider those one against the other. If we take the LINK programmes then, as I mentioned earlier, we do have some programmes which are specific for non-food crops because the Council saw the importance of that in Earl Selborne's day as an area of importance. There of course it is specifically aimed at non-food crops.

Lord Soulsby of Swaffham Prior *contd.*]

132. There is a feeling, which I am sure you are aware of, that since the change from EPSRC to BBSRC agriculture has come out slightly worse than the BBs of the BBSRC. Would you agree with that?

(*Professor White*) No, I would not. Indeed the contrary view is put to us by DTI very forcibly. My feeling would be that we have the balance about right. There may have been a reduction in the proportion of funding going into agriculture with BBSRC being formed. Then of course it changed its remit and took on board the science which the EPSRC was undertaking, so I would not see that your statement is true.

Chairman

133. Is the stark demarcation between food and non-food crops helpful? Presumably there are certain issues which researchers wish to explore that cross that boundary?

(*Professor White*) At the fundamental level it is not really because the processes that go on for improving food crops basically are the same processes which go on for improving non-food crops. In that sense it is not helpful. When you get to be funding the more strategic research and you are asking a particular line of funding to go a route which is aimed at a particular market, then clearly it is important to make that distinction. On the whole not.

(*Dr Yarrow*) Could I try a rather different answer to Lord Soulsby's question? It is to pick out from our evidence what I think is our four-fold strategy for supporting this area which is quite a powerful strategy for taking this area forward. At the first level we do have the responsive work which is important for plant sciences, funding there of four to five million a year across the spread of plant biochemistry, plant molecular biology. We then have that particular initiative of wealth creating products of plants, which is very much science driven. It is talking about how to manipulate metabolic pathways, novel ways of extracting products from plants. That is earmarked funding through this particular initiative. Beyond that we have our third layer which is our funding in conjunction with industry, 50-50 funding through LINK programmes. They are very much driven by the needs of the external community because we are looking for 50 per cent funding, so industry has a significant say. The fourth element of this on the back of all the funding we have been putting into the area and driven by that 1993 White Paper, realising our potential and looking for wealth creation, is how do we make sure that all this information is available to growers, processors and users, and some perhaps who have not been taking a sufficient interest in this technology in the past? Back in 1995 we worked with the National Farmers Union to launch ACTIN and you have I believe already met ACTIN representatives. We have put in 50 per cent of the funding of ACTIN for the last three years. We are now tapering this down, and our funding this year is something like 12 per cent, as we expect the market to take it over, but we see that as an outlet to make sure that our science is brought to the attention of the user community.

Lord Porter of Luddenham

134. I was going to say that in your memorandum you say that BBSRC support research underpinning crop biology irrespective of its end use. Of course there will be various priorities in there, particularly one perhaps which does raise a slightly different aspect of it, that there is a lot of discussion, in research councils in particular, about the value and importance of basic research and fundamental research against the economic return. As one example of this, there are very important developments in plant growing and processing technology. How likely are they to lead to better economic returns or how do their returns compare with advances in the fundamental understanding of plant biology with which you are also very much concerned?

(*Professor White*) Forgive me: I am not quite sure I understand the question. You are asking how do we get better economic returns from the more strategic research than we do from the fundamental research?

135. Whether you do. How do you compare them? You must have some priorities in deciding on your funding.

(*Professor White*) I would say that it is difficult to give a "this or that" answer. I would say that both are necessary and that they both contribute. If you are going to say which of them is the greater, then I think that the answer is that if you want an immediate return then clearly it is the plant growing and processing which you would need to develop. But of course the fundamental research is what underpins the future developments and I would say that over a period of time you are clearly going to get nowhere unless you fund the fundamental research. The long term answer is that the fundamental research provides the greater return; in the short term the immediate strategic one does.

Lord Porter of Luddenham: I quite understand. It is rather what I expected you to say.

Earl of Selborne

136. I wanted to address question 5 which refers to extrapolating results from university departments or the research institutes into the field. Perhaps you could tell us something about the process and experience, how easy it has been to get field scale trials of some of this work.

(*Professor Murphy*) In the oils area of business it is really just starting. There are small to medium scale trials of genetically modified lauric acid rape seed which is addressing the detergent market, going on in Scotland. From those trials we are learning things like hybridisation of this variety with normal food quality rape seed and that is very valuable. They are the kinds of things one learns from field trials. The field trials normally occur in conjunction with companies. They are on a large scale and need to deal with the growers. It is normally companies like Zeneca and Nickersons, Cambridge Plant Breeders, whom we would be working with. It is unlikely that this kind of work would be funded by a research council. This is a development phase of the problem rather than primary research. The problems are

Earl of Selborne *contd.*]

there, they are understood. They are the same kinds of problems that one has in developing any new variety, as we have been doing in agriculture for the past hundred years. I do not think the problems are particularly different. They are the same kinds of problems as we have had before, such as cross-contamination.

137. I wonder if I could ask whether in your experience you sometimes find that when you start doing the work on a larger scale you come up with completely different and unexpected results. For example, I remember on genetically modified oilseed rape there was an issue as to how far the pollen could transfer. On a small scale it appeared to be one figure but on a larger scale it appeared to go a lot further which was rather unpredictable. Is that an experience that you have had?

(*Professor Murphy*) That is exactly the reason for doing these field trials and for doing them on a farm scale rather than a plot scale. The same thing is happening in Canada that I am aware of when one moves to a larger scale. It also affects processing technology. Laboratory scale processing extraction may work but if you do it on an industrial scale suddenly you get all kinds of unforeseen problems. In both the growing and the processing we need to understand large scale problems, but that is not the primary research level. That is the development and it is very much in conjunction with commercial partners, the end users.

(*Professor White*) NIAB (National Institute of Agricultural Botany) would be often a partner who would take on, for example, seed that is developed, particularly in the institutes, and to some extent ADAS as well.

Lord Nathan

138. Are the environmental and ecological implications of non-food crops well understood? What are the main areas of concern? I have in particular in mind for instance the problems relating to oilseed rape. I am not talking about GM; I am talking about the adverse effect on people and animals, and also the impact, which is touched on in your own paragraph 24 and other paragraphs, of forestry (and I am thinking particularly of willow coppicing) on the water supply?

(*Professor White*) There is a whole range of answers, I suspect, to your question. On the whole the implications for non-food crops are not different from those for other crops. Alison Smith will give some answers about some areas where there are differences. On the whole they are the same kinds of problems. If you are going to ask what are the main areas of concern, they do indeed vary from crop to crop. You mentioned willow and short rotation coppice. I would think that the major areas of concern there are probably to do with rust rather than to do with water, as I understand it from the people at Long Ashton who were doing the fundamental research into this.

(*Professor Smith*) This is not really my area of expertise but in the non-food crop area we might well be looking to introduce new plants into our field. This is not really the case with food crops. There are established species. There are numbers of species that we might grow to produce particularly speciality products. Obviously, if we are going to start growing new crops there are implications for management regimes which need to be understood in advance. I believe that there are strict regulations about testing pesticide regimes that will be used on new crops. Obviously we need to know that those species will not hybridise with existing wild plants in this country and that is a very important consideration. If new non-food crops involve introducing new species into agriculture we do have to be very careful. That is well understood and there are regulations in place but it is an important consideration for new non-food crops.

Lord Williamson of Horton

139. On genetic modification what is the view of the witnesses about the potential for improvement? Do we think that the potential improvement in non-food crops coming from standard breeding technologies is greater or less than that coming from genetic modification? Where, if we think there is some potential in genetic modification, do we see the best developments? In your own evidence you do refer to one or two points, for example, the possibility of producing different fatty acids through genetic modification. What is your view on that? The second half of my question relates to the potential barriers, regulations, which may all be necessary but what is the effect of regulations on genetically modified plants? We are into a controversial area but also obviously quite an important one.

(*Professor White*) One that has taken up quite a lot of the Research Council's time in recent weeks.

(*Professor Smith*) We would not see genetic modification as being a completely different tool from the standard breeding technology. Both of these tools are useful and in some cases one would use both of them to address a particular problem. In my own area for example, if we are looking at developing new starches with different functionalities that will have specific industrial uses, many of the big companies concerned with this are using both genetic modification and more conventional breeding techniques and mixing and matching the two things as seems to be appropriate. There are some developments one might want to make in non-food crops where only standard breeding techniques are applicable. There are large areas which cannot be tackled by genetic manipulation because we do not have the fundamental knowledge to do that. For example, the production of complex chemicals like essential oils is a terribly complex problem. Those are mixtures of many chemicals that we do not fully understand. Conventional breeding will allow us to mix and match those chemicals. Genetic manipulation at the moment would be no use. There are other areas like the production of vaccines or antibodies in plants where clearly only genetic manipulation will allow us to do that. Plants do not naturally make those things and we have to use genetic manipulation. I do not think that I would look at the two things as separate ways of doing things. Some will be more applicable in one case than

Lord Williamson of Horton *contd.*]

the other and we would look at using both of them to achieve a particular end.

(*Professor Murphy*) Standard breeding technology has advanced amazingly in the last decade largely due to the application of biotechnology techniques like molecular marker assisted selection. That is like DNA fingerprinting for plants. This means that we can for instance produce disease resistance without GM by hybridising with resistant relatives of the plant. It would have taken decades previously. Now it only takes three or four years. The standard breeding itself has improved immeasurably and we can look forward in the next decade to doing things we could not have dreamt of before. We have to be aware that the advances are not just in adding genes. They are helping the conventional breeding as well.

140. How far do regulations at present restrict the facility of the research worker to arrive at what he is planning to do with it?

(*Professor White*) Up till now we would not see them as having impeded the research, and indeed as being a necessary part of the way that we operate. I do not think we see them as an impediment at all. Clearly the threats that come from some areas of concern that we should stop doing GM trials would be a massive impediment if that ever were to occur, but the regulations that are in force and the various regulatory bodies through which they occur, like ACRE and ACNFP and such like, we see as being a straightforward and proper part of the process.

Lord Soulsby of Swaffham Prior

141. Could I follow something up with Dr Smith? You mentioned vaccines and antibodies. Are you working on this in Norwich and how far have you got?

(*Professor Smith*) We have a group in Norwich which is introducing into plants parts of human viruses in order to produce vaccines to those viruses. This is a cheap way, a very easy way, to produce small parts of proteins which can be extracted in bulk to raise vaccines in a way which does not involve the use of animals and enables us to produce these things safely and in large quantity. I am afraid I am not up to date on the commercialisation but I know that actual clinical trials of some of the materials produced from this kind of study have taken place in the United States last year, so this is at an advanced stage and I think it is an extremely promising area. This would of course be a speciality use. You would not need tens of thousands of hectares of these things. It is a very interesting development in the use of plants to produce medicines rather than using animal based research.

Chairman

142. Might you be able to let us have a little more information in a note?

(*Professor Smith*) I am sure that we will be able to do that.

Lord Soulsby of Swaffham Prior

143. There are some interesting developments in the use of human food, putting epitopes into those for ordinary human consumption and then you get an oral vaccine effect.

(*Professor Smith*) That is right. I believe that there are scientists putting such things into bananas for human consumption.

(*Professor White*) Another area of advance but not funded by BBSRC is a technique called the "overcoat technology" which was developed at the Scottish Crop Research Institute, and they are collaborating with American commercial companies to develop that for the exploitation and development of vaccines.

144. I wonder if we may have further information here.

(*Professor White*) Yes, we can send you that. The person we will get the information from is Professor Michael Wilson who has just moved to Horticultural Research International from SCRI.

(*Dr Yarrow*) Some of the John Innes work on the vaccines I believe has been picked up and exploited by Axis Genetics whom I believe are now working on an edible vaccine for Hepatitis B in potatoes.

Lord Rea

145. This might be the right time to talk about question 29 of your evidence: "Depending on the nature of the modification it might be necessary to physically separate non-food crops from those used destined for the food chain and this will clearly have implications for the producer." How is it possible to do that other than in a closed laboratory condition? Surely pollen is sometimes wind blown and otherwise is insect carried. How can you actually get it to attack one crop and stop it interbreeding with another?

(*Professor White*) In absolute terms perhaps you cannot. I think the question here becomes one of risk and at what stage one is prepared to accept a particular level of risk. For the current examples of GM crops and for the cross-pollination there is really a whole background of information over many years, first of all with standard non-GM crops. There is a great deal known about that and the levels of risk of that are fairly well understood. I would answer that there is an acceptable level of risk at which stage you can proceed but that of course is a political more than a scientific requirement.

(*Professor Murphy*) We have been doing this for many years. We grow an industrial rape seed variety and have been doing so for the last 30 years. It is about five to 10 per cent of the whole crop. Farmers understand that they do not mix the two varieties and there is a certain isolation distance, a few hundred metres, so they grow high erucic rape seed under contract and it is tracked to a particular refinery where it is made into erucamides for plastics. The same farmer may grow on other fields rape seed for margarine which he sells to Unilever. The farmer has already had a great deal of experience in this. The farmer may grow linseed on the same farm for putty, again a non-edible crop. We have a very large knowledge base going back many years on how to

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manage these. The problem may be where there is a multiplicity of non-food crops, for instance where there is a pharmaceutical crop and a lubricant crop or a plastic crop and various food crops. That adds to the cost if you are segregating many different varieties and that is a problem really for the end users. I do not think that problem has been confronted yet. We have seen Monsanto who say they cannot even segregate GM soya from the regular commodity stream, so segregation is expensive. It is appropriate where it is a high value product but it could be a difficulty for lower value commodity type products. Transfer of pollen from non-food cultivars is a problem almost exclusive to oilseed rape. Other crops either self-fertilise (for example, wheat and peas) or are not propagated by or harvested for seed (for example, potato). For these crops, segregation problems arise only after harvest.

Lord Birdwood

146. Certainly the last sentence of paragraph 28 of your paper covers what I wanted to ask. I would like some expression from witnesses of their view of public attitude. Will it get worse before it gets better? Will it get more accepting before it gets more hostile? Have you developed a policy to respond to media questioning?

(*Professor White*) If I could take those in turn, with regard to will it get worse before it gets better and where is it going, I really do not know the answer to that. My feeling is that there are some issues which are clearly important and are being addressed and I expect that those questions being taken seriously and being seen by the public to be so addressed will start to allay the public's fears about them. In terms of what the Council is doing to put its view across, we are in the process of doing a review of two things. First of all there is what we are doing in terms of Council funding. We are also doing a review of what is known about GM issues; this will be considered by the Council at its next meeting. That will then lead to something rather more public being said than we have currently done except through press releases and the Chief Executive for example being on television and radio.

147. It seems to me that a benign response to genetic modification of non-food materials can be a Trojan horse for acquiring future public acceptability for genetic modification in a variety of what you might call more intimate environments.

(*Professor White*) I would agree with that.

(*Professor Smith*) The public may be quite ready to accept vaccines produced in plants for example. This reduces the use of animals in medicine. It is a wholly admirable use of plants as far as many of the public will be concerned, and that of course would be GM. Production of, say, modified starches and oils which can be used to make biodegradable plastics which overcome the pollution problems, the carbon dioxide problems and disposal problems of current plastics for example may find public acceptability, so I agree entirely, and I think we have a duty in public education to raise the potential of these things and point out the potential benefits of GM research.

Earl of Selborne

148. I wonder if our witnesses would accept that the responsibility, if there is a responsibility, for improving public understanding of GM extends far further than the scientists who are our witnesses. In some ways perhaps Parliament itself has a responsibility for contributing to this debate. I wonder if the role of the Research Council was well exemplified by Professor Blundell when he was Chief Executive of the BBSRC and set up a consensus conference in conjunction I think with the EPSRC and certainly in conjunction with the Science Museum. That at the time I think demonstrated that a forum such as that could effectively demonstrate public acceptability or otherwise of the science but there is much more beyond it, which is of course where the wheels came off when Monsanto determined that they could not separate the two streams of products, as we have just heard, which is nothing to do with the science but is something quite a lot to do with the public understanding of the risk. I wonder therefore, coming back to the role of the BBSRC, which I do not think should be confused with the role of so many other people, whether it is perhaps time to revisit the consensus conference type of approach which Professor Blundell did a remarkably good job on.

(*Professor White*) That of course did receive a great deal of favourable comment and still does, and I think we should take that comment back and consider repeating something of the kind. It is not on the books at the moment.

Lord Marlesford

149. I am a new member of the Committee; this is my first meeting. My background interest in these matters is that I am myself a practical farmer in Suffolk and I have an environmental interest in that I was until last year the Chairman of the Council for the Protection of Rural England and am currently President of the Suffolk Preservation Society. I really want to go on to that part of your paper at the end which is a., b. and c. on the last pages about the linkage between farming in the conventional sense and farming of non-food crops, and the extent to which you feel there is a linkage as far as both economic viability and environmental impact are determined. For example, with the arrival of setaside payments, the growing of non-food crops is obviously a very useful way for farmers of supplementing the revenue they get from setaside. Do you feel that the development of non-food crops is dependent on that sort of cross-subsidy which was really introduced not for that purpose at all, and do you feel there are other ways of encouraging non-food crops which might be more appropriate for example through differential rates of taxing a product?

(*Professor White*) I do not know that we have a competence within BBSRC to respond to that by virtue of our being BBSRC, if I can put it that way. Clearly at the moment there need to be financial incentives for many of these products to be grown. You would, I am sure, be able to answer this much better than we would. I do not really know what is the

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best way for that to happen as long as it happens in some form or other, through the subsidy you get through setaside or through the sorts of subsidies that are produced for the short rotation coppice provision for power stations, or in other ways. I am not able to give you a very clear answer. I do not know whether any of my colleagues have a better view than that. I am not being very helpful.

(*Professor Murphy*) Long term I think there is no doubt that we should not and cannot rely on subsidies. These products must stand on their own two feet as it were. That is certainly the aim of the kind of work that we do but that is a long term aim. We recognise that there is an interim period where we need to get these on to the market at least to test the market. There will need to be some measure of public subsidy. Certainly at the high value end, the pharmaceuticals, I do not think there is a problem. I do not think there ever has been. It is more at the medium and low value end that there may be problems. It is far too uncertain to rely on subsidies. We know they come and go and, looking to the future, one is very uncertain about their prospects in the next 10 years.

150. When you are saying that in the long term non-food crops have to stand on their own, we have had a very long term in which food crops have not been able to stand on their own. Is it a really meaningful distinction for this purpose in seeing how the arrival of non-food crops is going to develop? Do you really see that this can be separated out from the general regime that there is for farming?

(*Professor White*) I suppose I would say that it is essential that it were, because of the fact of oil prices that we alluded to earlier. They presumably are going to rise in the medium term and it behoves us to be ready when that happens. One of the ways in which that is going to be helped is by some of the non-food crops. It is important that we do the necessary research and get all the problems sorted out as to how that gets put into commercial practice at this stage rather than later. I would say that it was essential that a mechanism is found, although I am not giving much help on the mechanism itself, in order that we can prepare for that medium term.

Lord Middleton

151. I am sure Dr Murphy is absolutely right, that the research should concentrate on crops that can stand on their own without subsidy. That must be the right long term view. I was wondering what kind of crop products would come into that category.

(*Professor Murphy*) As I said, I think it is the high value ones which are the most secure: the pharmaceutical products, the antibodies that we have had, and maybe the biodegradable plastics, and some of the high value oils. It is not just non-food. There are things like fish oils which can be produced in plants, nutraceuticals, which are food additives, which can be produced in plants. We do not distinguish between food and non-food at our level. It is more the medium to high value crops.

152. We then come up against the difficulty which is, as quoted from the paper, that the high value crops are mostly grown in a very small area. What we are looking for in the long term surely is substituting food crops with non-food crops that can be produced in greater bulk.

(*Professor Murphy*) That is a genuine problem, and for some of the pharmaceuticals the entire world supply can be grown on less than 10 hectares, but that farmer will get a lot of money for it, i.e., it may be as profitable to grow 10 hectares of pharmaceutical crops as to grow 10,000 hectares of lower value crops.

(*Professor Smith*) May I speak up for some of these bulk crops. I think there is an enormous unrecognised potential for the use of some of these materials. I think we have a strong duty to educate, if I may put it like that, potential end users of the products. There are many companies out there making things from plastic which they might be able to make from plant products. It simply has not been considered. There is an enormous inertia within the system in my own field in that starch crops are bought by starch companies who then modify that starch and sell it on to the end user. The starch companies are extremely conservative by nature. Many are not prepared to experiment. They have got their users in their hands and they do not go out and look for other end users who might require different products. The whole system has an enormous inertia. I do not know what will come of it in the long term but we have had some very pleasing communications from people who have read small articles in the popular press, people who make signboards for example who contacted us and said, "Would it be possible to make these from starch? We are making them from plastic. They just get broken up, they litter the environment. People might want signboards made from starch." I do not think starch is practical but I was able to put them in touch with the BioComposites Centre in Wales which told them how they could obtain signboards made from compressed plant materials and those are I think now being taken up. That is a small example but some of these materials could potentially be used far more widely. I really do not have a feeling for the economics but I think there is a vast untapped potential use for these materials which may make a difference in the longer term to their viability.

Lord Marlesford

153. Environmental benefits are something enjoyed by society as a whole if you like, and it is often difficult to expect the producers voluntarily to use higher cost products. In the example you gave earlier, and indeed have just given, of the biodegradable packaging material, clearly there are huge environmental benefits from it being used and yet it may be that if it is going to be more expensive than the polystyrene, perhaps dependent on the price of oil, that may not be desirable. Do you feel if you stick to this idea that non-food crops must stand on their own feet you are going to get adequate use of these sorts of products where there is an environmental and difficult to value benefit for the producer?

(*Professor Smith*) I think this is again a matter of public education. Maybe we again have a role here in informing the public about these alternative

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products. There is very little information around about the potential of some of these products. There is no consumer demand, partly perhaps because they are more expensive but my feeling is that it is largely because they are not generally known about or available. It is quite possible that greater public education would create a demand for these products. Again I am talking very long term.

Chairman: Professor White, thank you to you and your colleagues. I am afraid we must bring this very interesting session to an end. If there is any further information you feel would be useful to this inquiry, we would be very grateful if you would let us have it. I should just like to end by thanking you and your colleagues very much for coming and at for coming at short notice.

Examination of Witness

DR DAVID BRUCE, Group Leader, Biomaterials Group of Bioengineering Division, Silsoe Research Institute, called in and examined.

Chairman

154. Dr Bruce, thank you for joining us and for doing so at short notice. We are most grateful to you. May I ask you to start by outlining a little bit your particular role and then perhaps following up with the first question on our list of questions as to what you see as the practical issues that hinder the economic development of non-food crops and to what extent these crops are specific or to what extent there are generic difficulties?

(*Dr Bruce*) I am the Head of the Biomaterials Group at Silsoe Research Institute which grew out of the National Institute of Agricultural Engineering. We carry out research and development in physical sciences for biological industries, including agriculture. I have been at the Institute for 23 years and I and my small group have been involved in a number of research projects relating to non-food crops. I have worked on drying of crops, principally on grain, latterly on biomass crop materials, and on projects studying aspects of harvesting of fibre and oil crops. My group was responsible for several developments in harvesting and processing, including the stripper harvesting system which was done before I was involved with the group, a machine for preparing cereal straw for pulping, and the decorticator system which is to separate fibre from the stem of plants such as linseed, flax and hemp. Other members of the Institute have been involved in non-food crops in carrying out studies of the economic potential for fibres from United Kingdom grown plants, and also lifecycle analysis studies. This may sound rather academic, but we do try very hard to ensure that our research is relevant to commercial needs and many of the projects involve commercial partners and result in technology transfer. I hope therefore to be able to comment on some of the practical issues influencing the production and processing of non-food crops. As you realise, I have had very little time to prepare for this morning's session.

155. If you would like a follow-up, please feel free to respond by letting us have a note instead. Could I ask you to comment a little further on those key practical issues that might inhibit the economic development of non-food crops?

(*Dr Bruce*) The question suggests that there may be some key practical issues that are crop specific and others may be generic, so I will start with the generic. Amongst these I would certainly list harvesting. There is a need to harvest the materials, which tends to happen in a very seasonal fashion, and therefore there may be problems with predicting the demand and trying to estimate the amount of crop material which will be required by the industrial potential user. Once the material has been harvested there are problems in storing it. One needs to store the material for perhaps quite extended periods of time and there is an opportunity then for the material to spoil through insects or micro-organisms. The drying of the materials can be a significant problem. As far as the actual harvest process goes, there may be special machinery needed for particular crops which may be rather different from the machines which a farmer would have for his conventional food crops. Therefore that is something of a disincentive for producers to try out a new crop material. It is possible that a contractor system may be used so that they do not have to buy the machine. They can use contractor services to carry out a harvesting system, and indeed this applies for other operations too. Sometimes it happens that in a bad year there is a very small window when the harvesting may take place and therefore the contractor is completely unable to satisfy the demand during that short time. Moving on to the second generic issue, transport, in many cases the materials that are being transported may be quite low density and therefore the costs of transport can be very high relative to the value of the material. In the case of hemp for example, the cost of transporting hemp bales is approximately the same as the price that is paid to the producer. What they actually get for it is completely swallowed up in the cost of transporting their produce to the processing site simply because the density of this crop material is so low. For almost any of the non-food crops, as indeed for food crops, there are potentially big effects of the season and many other factors on the quality of the material that is being produced. Indeed, in some cases the supply may be very limited because the harvest may be unsuccessful. There is of course the influence of subsidy and in my experience the potential user is very concerned that in many cases these crops are grown to the level that they are because of the level of the subsidy, and therefore if the subsidy is changed, something over which they have no control whatsoever, the supply of the crop material could be dramatically altered. In fact the raw material may completely dry up. There is in many cases a lack of established market so there are no regular suppliers or traders with a very high reputation. In that case it is worrying for the potential user because they may have no organisation from which to purchase these materials in the way that they are purchasing perhaps their oil based materials. There are two further generic issues. One is that if a potential producer is interested in trying new crops he probably knows a great deal about the agronomy of that crop because he can study that on a very small scale. He may know a lot about the product and about the marketing opportunity, but he probably does not know a great deal about the technology that may be required to produce that crop in significant volume because that is something that you cannot really investigate on a very small scale. Therefore we find that there is a block between a small plot that you can harvest by hand, and you can do various tests and evaluate the quality of the oils or whatever it might be, and the challenges posed by trying to grow the material on a field scale. On the field scale issue weed control is also a generic issue. There may be a strong desire to have a non-chemical means of controlling weeds rather than doing it by weed control chemicals, which in any case are almost certainly not approved for minor crops. Therefore perhaps some sort of advanced mechanical weed control may be required. In fact,

Chairman *contd.*]

my Institute is working on a system like that at the moment, which I thought might interest you. I will go on to talk about the specific issues. Coming first to fibres, the area with which I am most familiar, harvesting of fibre crops can be difficult because the virtue of fibres is that they are strong and tough. The material, which is basically a plant stem, such as flax or hemp, is very strong and particularly when it is wet it is difficult to cut. Therefore the operating the cutting the crop in itself is often a problem. If the weather conditions are poor and the machinery is not in absolutely first-class condition, the farmer can have a severe problem with the machine jamming or wrapping up with the crop materials, and I have seen some pretty horrible examples of that happening. In the United Kingdom we are trying to harvest flax using a combine harvester based system rather than do it on the continental system which involves pulling the crop out of the ground. I can go into the reasons for that if you would like me to, but the combine is unable to cut flax which is more dense than about 1.5 tonnes per hectare. This is going to be a serious limitation in the ability to extend that system to a realistic level of yield. The next major specific issue on fibres is to do with retting. Retting is an absolutely crucial part of the production of fibres under the current system and it has many drawbacks from the farming point of view and also from the point of view of the crop quality. First of all it takes up space. The crop has to remain in the field for some weeks and therefore there is a knock-on effect on the following crop material. You cannot get the autumn sown crop in. You may have to sow it in the spring. Retting has to be correct. It has to be done to the correct degree to get best separation of the fibre from the non-fibre material and yet the process is dependent on the weather. It is therefore something over which the farmer has very little control. As I have heard it said by an industrialist, "Your factory has no roof", so you have the crop sitting out there. It needs to be wet in order to ret, but when the end point of retting has been arrived at, it then needs to be dried so that it can be baled and stored without further deterioration. If it happens that drying conditions are poor at that particular point in the cycle, the crop could over-ret and the fibre will lose a lot of its strength. Water retting, as it used to be practised, is not acceptable these days for environmental reasons, but there are possible ways of retting in controlled tank-based conditions. It is also possible to extract fibre without retting and my Institute is currently working on a system to try and do this for hemp. It is not at all well studied yet. The retting is a crucial limiting factor in the production of fibre crops, and there are no instruments that you can take out into the field and measure the degree of retting of your crop to find out whether it is the right time to bale it. You have to do it by experience and of course many growers who are thinking about growing these crops have not got the experience to do that. Drying in the field I have refereed to. That is also in some cases a serious issue and may depend on the way in which the crop has been arranged. Storage thereafter is the next problem. Of course if the crop is too damp when it goes into stores there are almost certainly problems and possibly fires which have occurred in fibre crop storage. The separation of fibres, which is something that Silsoe has been working on for a number of years, requires specialist machinery and is certainly one of the areas where you can damage what is potentially a very good fibre crop where, if you do the extraction without the correct machinery or in an incorrect way, the fibre itself can be severely damaged and therefore lose a lot of value. I would like to make a few comments if I could about seeds and the fresh plant material such as leaves and flower heads. Seeds may be thought to be a very easy part of the operation because harvesting of seeds and grains and oilseeds and so on, is pretty well developed, but there are some problem areas. For example, some of the novel crops such as borage have a very indeterminate habit, so they produce fully ripe seeds on part of the plant while some other part of the plant is still flowering. These seeds can be lost if you harvest the crop at the wrong stage. There is almost no stage where you can harvest it without losing quite a lot of the potential seed. One could conceive of a system where successive harvests took place but that is probably going to add too much cost to be feasible. With oilseeds, like oilseed rape, the pods are very vulnerable and that is a problem which is currently being tackled. Some seeds are extremely small, such as evening primrose seed. It is very fine and therefore conventional harvesting and handling systems designed for grain or oilseed rape cannot cope with it at all. New systems will need to be bought by the farmer once those have been designed and worked out by somebody else. Drying and storage are again a problem. I do not think I need go into that further. If you are considering harvesting the fresh plant material, such as the leaves, of something which has a very high moisture content, there can be extremely little time between the point when you cut it off the plant and the point where it starts to spoil. One of my colleagues tells me that for mint, for example,—I know that is a food crop but it is typical of the leaf crops—you have about three hours between the point when you cut it and the point where it noticeably starts deteriorating. This provides a huge problem. You cannot do it in very large quantities because you cannot preserve the stuff within that space of time. It does suggest that these perhaps quite high value materials grown for their essential oils would only really be feasible when done on a very small scale. It could be quite a small plot of material and the grower would have a piece of equipment which he could cope with. These materials are often very sensitive to heat. You cannot put hot air through to dry them because you then lose the qualities or oil that you are trying to produce. For flower heads, and I am not at all expert on this part of it, I understand that the harvesting of flower heads is not easy to do. You might think you just go along and cut them off, but they do tend to occur at different heights of the plant and if you go through with a combine harvester you get a lot of stem as well as the head, and often the stem will yield some chemicals or oils which would effectively pollute the oil you need from the flower head. That is probably a quick rundown on the key factors.

Chairman: That is very helpful indeed.

Lord Birdwood

156. May I say how surprised I was that the diagnosis of a safe level of retting is still entirely a craft activity. Have you examined whether it changes its optical characteristics in a predictable way, because tobacco virus and rust can both be spotted optically long before they can be spotted under a microscope. I am wondering whether you have investigated whether a hemp or flax crop in the field change their optical characteristics sufficiently accurately and predictably.

(*Dr Bruce*) It is not something that my Institute has been involved in, but I do have a little bit of experience on this one. The simple way to assess the degree of retting would be to take a piece of the material, to dry it off and then to pass it through a processing system. This is how it is done in, for example, France and Belgium where they grow it by the traditional means. That of course requires that you have the ability to have it processed for you and to get some feedback on the processed quality. The possibility of having an instrument that you could take into the field to measure something about the crop material is certainly a possibility and there is a machine based on a near infra-red which is being developed by an institute in germany which claims to do this. I understand from comments that I have heard that it is not very effective. It is also very expensive so, whereas it might be suitable for a very large producer, for a smaller producer it is not going to be feasible. That is not to say that it could not be made more cheaply and perhaps more effective, but at the moment there is not such a device. I am sure there are means of assessing the biochemical content of the stems that might detect the approximate point of complete retting.

157. Do you feel that the balance between the various components of research is about right, or in your wish list is there one which you would like more resources devoted to?

(*Dr Bruce*) It is somewhat difficult to answer the question without appearing to be biased. As somebody interested in the technology of the production of these plants, I feel that there has been perhaps a disproportionate amount of effort on the biological aspects of the crops. For example, I was at a meeting not too long ago where problems of biofuel crops were being discussed and many comments came back from the farmers that they were in a position where they could go ahead now and plant the willow crop materials. They knew how to get that bit done, but when it came to the harvesting, the chipping, the storage, possibly drying on their farm sites, that bit was technology which they had not got anything like enough information about. It is certainly true that in the future we will need clonings of willow with better disease resistance, better yield and so on, in the very short term there is a lack of information available to the growers as to how to cope with the very practical issues. That is an example for willow crops, and the same sort of thing goes, I am sure, for a number of the potential non-food crops on the list.

158. I am assuming the Institute has a continuous dialogue with machinery manufacturers. What is the quality of that dialogue?

(*Dr Bruce*) We have a dialogue with machinery manufacturers for areas where we are currently carrying out research or where we have carried out research in the recent past, but we have not got the resources to have a dialogue with all sectors of the industry. As you may know, in the agricultural engineering industry many of the companies are very small. While we certainly have contact with all the large ones, with many of the small companies they are just too numerous to be in regular contact with. Information is certainly there about what those companies are interested in and where there has been an opportunity to work with them or to try and transfer the technology with their help, we would have access to that.

Lord Marlesford

159. By what means do you think we can get the environmental benefits from non-food crops? What steps can we take?

(*Dr Bruce*) It is a very interesting question. Some of my colleagues that I mentioned have carried out a lifecycle analysis for some aspects of crops, not specifically for non-food crops and certainly not for the generality of crops, but one of the things they have been doing is to try and harmonise throughout the European Union the various methodologies used for assessing the impact of crops in this lifecycle analysis process. I think that the methodologies are now coming to the point where they can be applied to a wide range of problems relating to agriculture. What they tell me is that if you apply these methodologies you do not always get the results that you expect, by which I mean that it may be that the benefits of growing non-food crops in the United Kingdom may not stand up to the lifecycle analysis and show very clear benefits. While it is possible that were the analysis to be applied benefits would be clear, it may also be possible that for example the cost of transporting these materials and the fuel needed to transport the materials could be more of an environmental disadvantage than the growing of them as an alternative to oil based products. Further work is needed to study carefully the environmental benefits of various non-food crops and to try and quantify where those benefits are to be found and then policies need to be put in place to maximise those benefits but not to encourage growth of non-food crop materials as if all of them had environmental benefits, which I am fairly sure they will not have.

Earl of Selborne

160. You have already given us an example of one process which has unacceptable environmental impacts. That is the old-fashioned water retting of flax. Are there other examples which come to mind where there is not in fact a green benefit, because after all products from non-food crops are often marketed as a green alternative?

(*Dr Bruce*) It is certainly true that they are all by their very nature renewable, depending on how much fossil fuel goes into their production. Essentially they are all renewable and carbon dioxide neutral and so on, so they do have green benefits. There may be various aspects of the process that would absorb

quite a lot of energy. If you are growing an energy crop then evidently you want to make sure that there is a lot more energy that comes out of the system than you put into it. If you are growing a crop, for example an oilseed, from which you want to extract some oil for a high value purpose, you can probably justify the amount of energy that needs to go into that crop in order to grow it and perhaps to dry it, which might take a considerable amount of energy.

Lord Marlesford

161. In your paper you refer to straw burning and the fact that the P and K will be lost if the straw is taken away to be burnt in a power station and the ash is distributed, which probably might be difficult to do. I think I am right in saying that it has been found that a great deal more in the way of chemicals, both for weed control and other pest control, is needed than was needed in the days of straw burning which in a sense achieved the same result as chemicals.

(*Dr Bruce*) I am not sufficiently well qualified to comment on that, although I have heard the same as you, that in effect the straw burning did carry out a certain amount of cleaning of the ground, and if that straw is going to be collected then perhaps there may be more sources of infection or for example slug problems than if the straw had been burned. I am not sure if that is the case or not. I know that there is relatively little knowledge about what would be the effect of perhaps chopping and incorporating the straw instead of burning it. The knowledge on that has been increasing over the past few years but I am afraid it is not a subject that I have followed closely.

Lord Porter of Luddenham

162. I wonder whether Dr Bruce can tell us what factors he sees as discouraging potential users from using materials from non-food crops and how these barriers might be overcome.

(*Dr Bruce*) I can really comment mainly in terms of fibre crops. Many of the comments are probably generally applicable to other non-food crops also. The first would be in technical performance. If a potential user is considering whether to use fibre from, let us say, hemp rather than a material which is based on, for example, polypropylene, they would need to be sure that the hemp fibre would be able to perform adequately in whatever application they were thinking about. That would be performance in the production of the product. Perhaps it might be a spinning or weaving or pressing operation. Then, once the product was in place, there might be problems of water absorption if the material is being exposed to a damp environment. Hemp fibre untreated would absorb water quite strongly, whereas polypropylene is hydrophobic and would not absorb water. That would perhaps lead to biodeterioration. In some cases it might be you would want to achieve that, but you may wish to have control over when the process starts to happen. Technical performance might be the first issue. In many cases the natural fibres have benefits and they have disadvantages compared with the synthetic alternatives. ...My view is that in a lot of cases the industry concerned needs to reconsider the design of products so as to try and take advantage of the benefits or the positive technical factors, but also to try and work their way round by appropriate design the drawbacks of some of these materials.

163. Is information or lack of information a problem in this respect with respect to potential users?

(*Dr Bruce*) I think it is, yes. I think that potential users are not familiar with the alternatives to the synthetic produced, in my case, fibres as raw material.

Lord Williamson of Horton

164. Can I ask if there are some uses where the differences in quality of a fibre are not as important as all that? I have in mind for example in construction where a lot of asbestos has been replaced and there are potential uses for fibreboard of various kinds in buildings. I had the impression that quality is not so important in some of those uses. I do not know if that is true or not.

(*Dr Bruce*) Certain aspects of quality must be important because the product is required to perform in a certain way. If plant fibres are capable of achieving that performance, the next major factor preventing their uptake would be price. Several surveys have shown that the price/performance ratio of the natural fibre is in many cases somewhat higher than for synthetic alternatives.

Lord Porter of Luddenham: I had better mention, my Lord Chairman, the cost of taking out the asbestos boards after they had put them all in.

Lord Middleton

165. Dr Bruce has already referred to certain aspects of machinery and equipment. I wonder if I might ask a different question following up on our last session. Dr Bruce mentions this POST note 125, which seems to be a very relevant document.

(*Dr Bruce*) I would agree. It is a very well written document.

166. Which mentions a huge range of possible non-food crops. I wonder if he could say, assuming it is a crop which can stand on its own economically without a subsidy and assuming secondly that it is grown on a fairly large scale, which he might select from his own experience as being the most promising from this large list?

(*Dr Bruce*) The most promising one in the short term must be biofuel material, the one which is nearest the point of being economically able to stand on its own feet. It is the one which is now being taken up commercially in a significant way, I am sure you realise from that publication and other things. It is certainly one which the policy of needing to satisfy the Kyoto Agreement is driving us towards. In the short term that is the one that I would pick as being my favourite. In the longer term I think it is essential that we have the ability to produce many of our industrial raw materials from crops, be they genetically modified or otherwise. I feel very strongly that in the longer term, and we are talking perhaps of

Lord Middleton *contd.*]

20 or 30 years, we need to have the technology and the biology in place which will enable us to substitute the materials produced by crops for materials which we currently take from fossil fuels. In the longer term I think the ability to produce speciality chemicals of all sorts from crops is probably going to be equally important.

167. At a former session the question of hemp was mentioned. Could you say what potential you think lies in the production of hemp?

(*Dr Bruce*) Are you thinking in terms of using a significant amount of United Kingdom land or in terms of the industrial potential for hemp?

168. All.

(*Dr Bruce*) The fibre crops such as hemp have a lot of potential for certain uses and those uses would include things like construction board, as was referred to, materials which are in effect consumed. They are currently being built into various parts of automobiles for which they have extremely suitable properties. I should like to see them used much more to substitute for glass fibre because there are major problems in both the production and also the final disposal of glass fibre which renewable crops like hemp would overcome. It is going to be quite a long and slow process because, as I referred to earlier, the design aspects of industry need to take into account the way in which these crop materials age. The production needs to take into account how to handle them and how to process them successfully without adding excessive costs. That will take some time.

Chairman: Thank you very much indeed, Dr Bruce, for giving evidence to us and enlightening us a great deal on a number of practical issues. The Committee is most grateful to you and if there is any further information you would like to provide us with for this inquiry we would be even more grateful. Thank you again.

TUESDAY 4 MAY 1999

Present:

Birdwood, L.
Hogg, B. (Chairman)
Marlesford, L.
Middleton, L.
Nathan, L.
Porter of Luddenham, L.
Rea, L.
Selborne, E.
Soulsby of Swaffham Prior, L.
Williamson of Horton, L.

MR PETER BILLINS, Chief Executive, MR MURRAY CARTER, Technical Adviser (ex-Chairman), and MR SILVAN ROBINSON, Chairman, British BioGen, called in and examined.

Chairman

169. Gentlemen, welcome and thank you for coming to give evidence to the Select Committee. I believe that you have had a quick look at the areas that we want to cover. I am sure that, like members of the Sub-Committee, you will use them as stepping stones for the questions to be posed or perhaps ignore them altogether. Perhaps you would briefly introduce yourselves and say anything that you want to say by way of introduction.

(*Mr Billins*) I am Peter Billins, Chief Executive of British BioGen. On my right is Murray Carter, the founding Chairman of British BioGen. His major business is the development of planting materials for short-rotation coppice. On my left is Silvan Robinson, CBE, the current Chairman of British BioGen. He has extensive experience in the energy business having worked for Shell in a variety of senior roles.

170. We had a most interesting visit last week to see stuff on the ground and that provides us with a perfect opportunity to question you about its development. Where do you rank bio-mass in terms of its potential as a source of renewable energy? Of the bio-mass sources, which have the greatest potential?

(*Mr Billins*) Most authorities would agree that bio-energy and bio-mass will be the most important source of renewable energy as we move away from dependence on fossil fuels towards greater reliance on renewables. Currently, bio-energy collectively accounts for about 82 per cent of the renewable energy resources in the United Kingdom as we speak. For example, wood as a fuel is already larger than large-scale hydro as a renewable energy source. Globally, it is reckoned that new plant growth—that is, the potential source of bio-energy—is currently five times total energy demand. Our primary sources of bio-energy are agricultural and forestry residues—the by-products of normal agricultural and forestry activity—and dedicated energy crops. We see an important role for each of those sources of bio-energy in equal proportion.

Earl of Selborne

171. That deals with the central part of Q2. You have cited 82 per cent as the percentage of renewable energy derived from bio-mass. Is that proportion likely to change over the next 10 years as renewable energy increases as a percentage of the total?

(*Mr Billins*) If we look at analyses of countries that are further down the path of developing renewable energy, that kind of ratio appears to emerge. That is the ratio in the European Union's take-off plan for renewable energy where bio-energy is a predominant resource. It is in the range of 60, 70 or 80 depending on the country, availability of large-scale hydro and other very significant renewable resources. Those are the kinds of numbers at which one must look.

172. Do you expect the dedicated energy crops to increase as a percentage of residue crops?

(*Mr Billins*) Substantially in future. Our belief is that agriculture and forestry have a key role to play in producing the fuels of the future. If we go back one hundred years 40 per cent of land use in the United Kingdom was devoted to energy crops. We do not consider the oat today as an energy crop, but in those days it was a fuel for horses and was one of the most important transport fuels. If we take Oxfordshire and Buckinghamshire where there are still substantial areas of old coppice, that was the source of fuel for London prior to the greater exploitation of coal. In 1750 one would have bought wood for fuel produced in Oxfordshire or Buckinghamshire for one's house in Kensington.

173. If one considers the traditional sources of energy in the form of derelict woodland on so many farms, which are no longer dedicated energy crops, can one envisage those being restored to use in competition with, say, willow plantations?

(*Mr Billins*) The opportunities and the requirement for the fuel is so great that we do not see competition between dedicated energy crops and what we call dependent resources. We see them working very much in tandem. That resource which is available today in the form of existing forest residues from conventional forestry operations and derelict woodland is what enables projects to get going today. At a later stage the dedicated energy crops can come in to serve those projects. But certainly the demand for wood as a fuel is increasing greatly. For example, we promote the use of wood as a fuel for heat. Recently, we have run the numbers relating to the impact of the climate change levy on this particular market. Wood as a fuel with the climate change levy is now the most cost-effective fuel for heating. That market is poised for substantial growth.

Lord Rea

174. The $64,000 question is: given current technology and the absence of support, what is the cost of electricity generated by bio-mass compared with that produced by fossil fuels like oil, gas and coal, although coal is being phased out?

(*Mr Billins*) In the last round of the Scottish Renewables Order wood-fired projects were let at 4.6p/kWh. We suggest that a more realistic price for wood generation is about 5.5p/kWh. However, I stress that that is the cost of generation. The real cost of electricity is about 50 per cent the cost of generation and 50 per cent the cost of distribution. Therefore, the customer pays perhaps 8p for his electricity. Most of our electricity is generated very close to the customer. Therefore, it tends to travel no more than about 20 miles, whereas coal generation in Yorkshire and consumption in Cornwall must carry a substantial transport overhead.

175. Can you give a projection of future costs in, say, 10, 20 or 50 years?

(*Mr Billins*) We have prepared some detailed written evidence that we shall submit following this meeting. In that evidence we say that the international view appears to be that if we can produce bio-mass at $40 per tonne that equates to oil at $10 to $13 per tonne. The current cost of production in the United Kingdom is about $60 per tonne. Therefore, our target is to produce bio-mass at about $40 per tonne. That brings us almost level with a barrel of oil. Those are the kinds of objectives that we wish to achieve. Most new technologies and markets have a rapid cost decay cover. We envisage that perhaps over five to 10 years we will be very close to oil at about $10 to $13 per barrel.

Chairman

176. Therefore, you can achieve $40 per tonne in five to 10 years?

(*Mr Billins*) Yes.

Lord Rea

177. For this purpose have you included or excluded agricultural set aside support?

(*Mr Billins*) At the moment we require an equivalence of support.

(*Mr Robinson*) The present problem is that industrial crops, specifically energy crops, are severely disadvantaged under the support mechanisms of the Community farming system. It is therefore inevitable that energy crops are disadvantaged in this way. We have always said that the level of support of energy crops is not important but they should at least get the same support as traditional agricultural produce.

Chairman

178. Have you factored into the $40 per tonne a particular level of support?

(*Mr Robinson*) Yes, but a declining level of support. I believe that over 10 years we shall come down to that level. It is a matter of improved yields, reduced establishment costs, better harvesting techniques and a whole range of things on which cost decay can be achieved. I believe that at the end of 10 years without substantial support the figure can come down to that level.

(*Mr Carter*) We certainly aim to do that. However, the prominent issue in the mind of the farmer is what he may get from other cropping systems. If there is a disparity between the energy or non-food crops and conventional food crops clearly there will be a disincentive for farmers to move into non-food crops.

Lord Rea

179. Quite apart from the incentive to farmers to move over to bio-mass, I want to disentangle the total amount of support and compare it with fossil fuels. I do not know by how much more the cost would go up to $60 per tonne if there were no support?

(*Mr Billins*) If we do not get the crop planted and established in substantial quantities in the United Kingdom we shall be unable to develop the expertise with the crop or achieve yield improvement and all the other things that must happen. When one plants 100 ha one does not go up the learning curve as quickly as when one plants 100,000 ha. Volume is very important, and that is just one aspect of cost reduction. Another is improved yields. The numbers that we have run at the current $64 per tonne price assumes a yield of about 12 oven-dried tonnes per hectare. To achieve the $40 per tonne price we must go up to perhaps 18 to 20 oven-dried tonnes per hectare. We envisage that being achieved with substantial planting within a 10-year time horizon. The issue of support or not has as much to do with farmer expectation as other factors. A farmer will not plant a crop unless its major contribution to the bottom line is subsidy. At the moment for the average arable farmer about 45 per cent of the gross margin comes from the subsidy component. If one removes that one will operate on a level playing field and one can achieve that. In order to achieve that reasonably large deployment one must be in a position to have equivalence. We are competing without subsidy with crops with subsidy.

(*Mr Robinson*) The numbers that have been run indicate that assuming these improvements in yield and mass deployment within 10 years one can get along without subsidy.

Lord Marlesford

180. As far as bio-mass is concerned, I want to explore the current $64 per tonne and the competitive figure of $40 per tonne for oil. In each case is that the price delivered to the power station?

(*Mr Billins*) Yes.

181. If one considers oil, it tends to be produced through a tap which can be turned on and off. In the past four months the price of oil has gone up from $10 to $16 per barrel. That is a major fluctuation with which producers can cope to some extent by turning the tap on and off. How does that correlate with decisions to produce bio-mass which appear to be pretty long term and where the tap cannot be easily turned on and off?

Lord Marlesford *contd.*]

(*Mr Billins*) If we look at forest residues as a resource, forestry is going through a substantial harvesting phase at the moment. There is greater availability of that resource as we speak. The interesting thing about bio-energy and bio-mass is that one can decouple the production of the crop from its utilisation as an energy source. The way to do that is to convert it into something called bio-oil. The current technologies now being demonstrated in the United Kingdom can turn wood into bio-oil, which means that one can fully decouple it from utilisation. That is very important. It means that one can build up stores, transport it and have it wherever it is required in as much or as little a quantity as is required. One of the key features, and perhaps strengths, of bio-energy, is that one has a renewable resource that is decoupled from its utilisation.

182. Do you mean that the wood is converted into oil and that resource can be stored?

(*Mr Billins*) Yes.

183. Where does that conversion take place? I presume that it does not take place at the power station or, presumably, the farm?

(*Mr Billins*) It can be done at a power station or fuel processing plant.

184. Do such things exist already?

(*Mr Billins*) It is already happening in Canada. Currently, there are two planning applications for NFFO projects where the intention is to make bio-oil.

185. I understand your point about an existing forestry operation with a by-product of forest waste, which answers my question about the oil tap. However, it does not immediately answer the point about the growing of a crop with, say, a 15-year rotation.

(*Mr Robinson*) One cannot get away from the fact that it is a dedicated crop. That is part of the process. It will be planned into electricity plants and will be part of mainstream electricity supply. One cannot avoid it being an integrated linear business.

186. But the marginal cost of the waste from existing forestry is a different factor from the total cost of growing willow deliberately on a 15-year cycle?

(*Mr Robinson*) There is a buffer, but whether an electricity plant will want to run at 70 per cent is another question.

187. But somebody must pay a fixed price over the 15-year period before someone takes a 15-year decision?

(*Mr Robinson*) It is desirable. There are a number of risks for the power plant: the supply risk, price risk and technical risk. One can take away the supply risk. Whether the price will be the same over 15 years is another matter. Under NFFO there is a stabilised price. As one moves towards a more liberalised electricity regime one suspects that that will not be so firm.

188. To go back for a moment to the distinction between by-products from ongoing forestry and planting, can you give any guidance as to the approximate proportion of the bio-mass that is likely to be produced which will come from those two very different sources? In other words, the by-product is a very long-term matter in the sense the crop has been growing for 30 years or perhaps 100 years. That factor is not easily variable in output terms. What is the proportion of bio-mass from wood which will come from by-products of forestry and specific planting?

(*Mr Billins*) Over 10 years the dedicated crop source will predominate.

189. You mean that it will be more than 50 per cent?

(*Mr Billins*) Yes. I estimate that over a 20-year period recognising growth in the market the dedicated energy crop will become the more important source. One can view residues as almost the swing producers for the market, very much as the Saudis play the oil market now. But the primary resource will be the dedicated energy crop. What a power plant developer is looking for is an element of guarantee of fuel supply. If one can guarantee that one has a dedicated resource that can be contracted and tied to a particular plant.

190. A large component of the production of these crops is labour costs. You made reference to the horse and oats and the early production of wood. I suppose that the biggest significant change in the world since then is the huge rise in labour costs without a comparable reduction in productivity. Do you see an increase in productivity, for example in terms of by-products of existing forestry, where the biggest part of the cost must be labour? Do you see the potential for mechanisation other than possibly in some very big Forestry Commission forests?

(*Mr Billins*) There are two components here. We return to one of the key planks of sustainable development: the prudent use of natural resources. When one chops down trees today one leaves anything between 30 and 50 per cent of the wood in the forest. If one had to replant that forest one would have to go in and gather up that wood, so there is a cost attached to it. By not utilising the whole tree one is making the saw log business less competitive. If one is able to command a full price for those trees, albeit a lesser price for the energy component, one is making one's forestry more competitive. That is the key issue. Another issue is that there is quite a lot of work being done at the moment on harvesting. One can envisage great improvements. For example, Murray can describe the progress in planting machines.

(*Mr Carter*) I believe that the advantages will arise particularly in the dedicated energy crop sector in bringing down costs. As you rightly point out, in the forestry residues sector there are advantages of scale and marginal cost. But the big benefits when it comes to pulling down costs will arise through a combination of raising yields, with which I am particularly involved, and at the same time reducing harvesting costs through more efficient methods. Perhaps I may pick up the question of the relevance of price fluctuation and the attractiveness of these crops. We are at the outset of a vulnerable industry and therefore if growers are to come in they will need to have a contract which they believe will sustain the business for at least 15 years. While that is an essential prerequisite at this stage, once we see a substantial industry developed with multiple outlets

the possibility opens up for the development of a spot market which trades in a similar way to some of the other primary energy sources. It is crucially important that we have protection initially through extended contracts to bring in growers, but ultimately I see the market as being a combination of contract, spot and probably a large number of individual initiatives by growers or companies with an interest in marketing heat and electricity locally.

Lord Nathan

191. I just wonder whether the National Forest project which covers enormous acreage has any relevance to this discussion.

(*Mr Carter*) It is unfortunate that a number of initiatives of the National Forest-type have chosen to exclude the very short-rotation crops from their programme. It is unfortunate because it offers the opportunity to farmers in particular to find a way to use their land for fibre and energy applications. The industry would be very grateful for a greater opening into initiatives like the National Forest and equally the South West Forest which exclude short-rotation coppice. It is of crucial importance because we seek to develop not just feedstock systems but also markets. Obviously, those markets are applicable to conventional forestry as well. One point that is frequently overlooked is that, far from being in competition with the conventional forest industry, we see ourselves as being very much in collaboration and jointly developing a whole plethora of non-food outlets. We have talked of energy. Fibre is another area in which I am very closely involved. We have just put 500 tonnes of short-rotation coppice willow through the Caberboard plant at South Moulton to produce chipboard. There is a whole range of potential markets in the bio-chemical side of things. There are also other uses. If we can combine in the National Forest and other similar community forests the development of conventional forestry techniques and the shorter rotation systems it will have a positive effect all round.

192. Are you promoting that idea or is it just one that you are putting forward to this gathering?

(*Mr Carter*) I promoted it at the very early stages of the National Forest; likewise, with South West Forest. Regrettably, in both instances the more conventional view has prevailed.

Chairman

193. I understand you to say that over a period of 10 years you believe that you can achieve $40 per tonne without any subsidy in the cost of production. You have talked of the need to encourage the establishment of the crop, but at that point when you make that calculation there is no subsidy?

(*Mr Carter*) That is correct.

194. In making that comparison, where you argued that this was competitive with oil at $10 to $13 a barrel, what assumptions do you make about the taxation regime, the fossil fuel levy and so on?

(*Mr Billins*) At the moment, none. We have been developing a response to the climate change levy consultation and recently we have run the numbers. We are beginning to view wood as a fuel as very competitive as a result of the climate change levy.

195. What about the non-fossil fuel obligation?

(*Mr Billins*) That is very important because it addresses another part of the equation. We have to develop the fuel supply infrastructure in renewables and the market through power stations. We view the non-fossil fuel obligation very much as an enabling mechanism to develop the market. One can begin to look at cost decays in equipment as more and more power stations are built. At the moment they are very much one-offs. Assuming that we begin to see substantial deployment, they will follow the classic cost decay curve for technologies of this kind.

196. When one considers the possibility of greater efficiency, does it lie in improvement of the crop itself, in processing, handling or power generation from these sources? What do you see as the prime source of efficiency gains over the 10 years?

(*Mr Billins*) It is a combination of all those factors. We can look at good yield improvements and increased mechanisation. I tried to prompt Mr Carter earlier to describe the new planting machines. When I first became involved in British BioGen planting machines would do a hectare a day. I am aware that there is now a machine that can plant a hectare an hour. One can begin to see quite substantial cost reductions in that area. One can begin to look at the ways in which the equipment within the power stations also comes down in price. I cannot identify one single factor; it is a combination.

197. Therefore, your $40 is based on across-the-board assumptions, not real perceived changes?

(*Mr Billins*) It is a highly conservative view of what happens to cost decays in novel capital equipment. It is a clear view of yield improvements. For example, the Long Ashton Research Centre plantation can today deliver 20 oven-dried tonnes per hectare. We believe that we can achieve that in 10 years. What one does in a research plantation takes a wee while to become the general practice.

(*Mr Carter*) The crucial point is that whichever of the three groups one looks at it is the repeat items that deliver the greatest benefit. If one takes yield as a classic example of that, obviously that occurs year in year out. As to yield improvement, with the very latest clones in research plot trials up to 22 dried tonnes per hectare per annum have been achieved. That has been a three-fold increase over the past 10 years. I stress that that has been achieved in trials, not in the field. However, it demonstrates that the potential through plant breeding to enhance yields—of course, it must be matched with improved agronomy—is very substantial. To give an idea of the highest yields achieved in Sweden, with long day length and ad lib moisture and nutrients up to 34 dried tonnes per hectare per annum with short-rotation coppice willow have been achieved. I quote those figures with caution because clearly they will not translate into field production, but they show not only the potential of the crop for improved yield but that it is linked in to the ability to retain that yield, so there is better disease and pest resistance and better understanding of where a particular variety will

Chairman *contd.*]

thrive, which is all-important. If one then goes to another repeat item, obviously harvesting is a classic example. As Mr Billins rightly pointed out, planting cost rates have gone down and yield rates have shot up. We see possibly similar progress with harvesting. On the power generation side, obviously there is the possibility of using imbedded generation with the utilisation of the heat as well as power. Obviously, that confers a whole new set of benefits in terms of useful product.

Lord Soulsby of Swaffham Prior

198. Turning to research and development, are the current research programmes directed at the right objectives? Are you instigating this research or is MAFF doing it? Who else is in the field?

(*Mr Carter*) A great deal of research is going on in both the United Kingdom and across Europe. The United Kingdom and Sweden are particularly prominent in this area. The issues that we need to look at are related to funding and the scale of it. We have an industry that is ready to move aggressively given the opportunity. There is a whole range of areas into which we would like to see funding put more actively which we as an industry would match. There is a need for greater resource research, particularly at the outset. We do not look for long-term support to get the ball rolling. We have got to the point where some very clear needs have been identified by the industry. Very often the industry is remote from the decision-taking when it comes to the allocation of the resource. It is absolutely critical that the resource should be directed by industry into those areas where it can bring the greatest benefit most quickly. Another area that has been neglected to a degree is the fundamental underpinning. We have a particular demonstration of this in plant-breeding, in that while we have the performance from the very high-yielding clones we cannot identify exactly what it is that contributes to that yield. The basic underpinning science that would enable that to be established would allow us as plant breeders to move forward into replicating the particular characteristics which give high yield. To move on to the European dimension, while an awful lot is going on and some very valuable work is being done there is a pressing need for co-ordination. There is a real disparity between the objectives within the climate change documents, the energy directorate and seemingly within DGVI, the agricultural directorate. Probably more than anything that is where there is a pressing need for a long, hard look. We need to see much more closely co-ordinated decision-taking.

199. You referred to work being carried out mainly in this country and in Sweden, but are there other countries within the Europe who are engaged in this?

(*Mr Carter*) It applies right across Europe. I sit on the advisory group to Franz Fischler in DGVI. We see a domination of a lot of those meetings by particular sectors. What is crucial is that a much broader perspective is brought to bear. Obviously, there is a whole range of energy crops or non-food crops.

200. Are we talking about both short-term biomass crops and also short-term coppice? Does what you say cover the whole range of fuel crops?

(*Mr Billins*) Very much so. One difference highlighted by work in this country between the short-term or annual crops and the perennial ones is that the energy balances tend to weigh favourably towards the perennial crops simply because they are not planted each year and there is not the same land work that goes on. One is not putting energy into turning over the soil regularly.

Chairman

201. What about the cost comparison?

(*Mr Billins*) Currently, the focus for market development and research is on those which potentially are the most competitive. In the United Kingdom short-rotation coppice and perhaps miscanthus are those that are closest to market. That does not mean that we must not look at the other crops; we must do so. We have to develop options and diversity is very important to us. Initially, short-rotation coppice and miscanthus are the most competitive.

Lord Soulsby of Swaffham Prior

202. Dealing with short-term miscanthus and willow, what is the relative emphasis of research into one versus the other?

(*Mr Carter*) It is weighted heavily towards willow. Research into miscanthus is far more limited. Research is moving particularly towards poplar and willow.

203. What is the reason for that? One would have expected annual cropping to be the better option?

(*Mr Carter*) Miscanthus is not an annual crop but a perennial crop which is harvested annually. But miscanthus is a grass which has developed in higher radiation—warmer—zones and is moving into a temperate zone. It can be done but it will take time. In terms of its introduction into the market, it is probably five years behind the short-rotation coppice willow and poplar.

Lord Middleton

204. When we looked at short-rotation coppice a week ago some of us considered the incentives to the farmer to grow it, the difficulty of grubbing up, the high cost of establishment, the question whether set aside payments would continue after 2006 and the instability of forestry policy with regard to grant schemes. I managed forestry for 40 years and the grant scheme and regulations changed regularly every five years. Given all those worries about going for a 15-year projects farmers may well turn their eyes towards miscanthus. Can you say a little more about how you see the future in terms of both power generation and providing something for farmers to do?

(*Mr Carter*) I believe that you were looking at the ARBRE project. Miscanthus is not suitable for production in the north of the country.

Lord Middleton *contd.*]

205. Why not?

(*Mr Carter*) Largely because it is out of its range and so yield performance is likely to fall dramatically. Where miscanthus will have a role is in the south of the country. The distinction between miscanthus and some of the other grasses is that there are grasses which have evolved in temperate areas that may well be suited to use further north. As time goes on with plant breeding of miscanthus we may well be able to introduce, as we have with maize, varieties that can be used further north. But for the next five years we believe that the prospects for miscanthus are limited to the south of the United Kingdom. You asked why a farmer might grow a crop of this kind. As a farmer myself, a dominant issue at a time of clear uncertainty like the present is diversification. The view I have taken—talking to farmers around the United Kingdom it appears to be a predominant view—is that the ability to diversify into a new sector, not with the entire farm but as part of the business, is potentially attractive, particularly if it can be linked to long-term contracts. If one takes the ARBRE project as an illustration with a 15-year index-linked contract, the figures potentially look very attractive particularly when set against the prospect of falling values attributed to other commodities.

Chairman

206. We visited a project last week. What sticks in my mind is that a self-standing project cannot achieve finance. While it may appear attractive, one will not get a 15-year contract unless one can get finance?

(*Mr Carter*) Certainly, that is crucial. You may be aware of the projects in Northern Ireland that John Gilliland has put together. Here we have a different approach in that the landowner has agreed to grow the crop but his objective is to add value. A very important characteristic of smaller schemes is that, for example, there is the possibility of not marketing the wood chip as such but moving on down the production line and marketing heat and power. If one compares the situation with conventional crops where the process is already largely allocated to mainstream players, the short-rotation coppice side of it and possibly also miscanthus offer an opportunity to get into markets downstream of the farming business. That is another significant reason why more business-oriented farmers are looking at it.

Lord Marlesford

207. Presumably, the time required for establishment and so forth is very different according to the crop. Miscanthus is a grass. One supposes that it can be easily ploughed up again quite quickly.

(*Mr Carter*) Miscanthus is not that different from willow. One grows the crop from a rhizome as opposed to a cutting. The rhizome is planted in the spring and grows on free air and is then cut back. One is then into a perennial cropping situation, in the sense that the rootstock remains in the ground for a number of years. With miscanthus one harvests it annually. Depending on the system adopted, in late winter and early spring one harvests it on an annual basis.

208. Therefore, you have to wait for only one year to harvest?

(*Mr Carter*) Initially, there is a very light harvest.

209. So, it may be two years as opposed to four?

(*Mr Carter*) Two years is a fair indication. As to willow, at the moment we have a three-year rotation due largely to the nature of existing varieties. But I can see a situation in perhaps four or five years' time where for cash flow reasons and/or because the productivity of the crop has risen substantially there is a move back to shorter rotations, perhaps two years. One year is unlikely. But an important distinction to make is that in both cases one is talking of a perennial rootstock; in other words, it is in the ground for many years. Perhaps I may dispel one other misconception in regard to reclaiming the land for agriculture. I have a lot of experience of restoring land from willow coppice particularly back into agricultural production or clearing. It is not a deeply-rooted crop in the sense of trees. One is not effectively creating forestry rooting conditions. A standard agricultural plough is sufficient to turn over the stools. One then simply rakes them up and burns them. One can get back into agricultural production within a matter of a few weeks without a great deal of difficulty.

Lord Birdwood

210. What changes to the National Grid would be needed to support the construction of small bio-mass power stations? Is it desirable to focus upon the development of small bio-mass power stations? This may provide you with the opportunity to talk about "scaleability" and the impact on social engineering. For example, would one go down as far as the parish power station? The attractions of having one's fuel source so close to a gasification and power plant are obvious. Have you developed a computer model in which you can put such variables to determine the cost of a very small power unit?

(*Mr Robinson*) The nature of the electricity structure in this country and generally is changing in a very interesting and remarkable way. For technological and market reasons the conventional system of having large power stations sited on top of coal mines, or nuclear stations sited on the coast, and pumping electricity down the grid and then down the wires of the distribution sector to the customer is beginning to change. One finds that the technology of small-scale stations is becoming much more attractive. One sees the nature of the business moving from a central hub and spoke system to one where increasingly there are small-scale peripheral stations that avoid the losses and investment and, more importantly, a distribution network. This is liable to cause considerable pain to those who have large power stations and who have invested in the grid, so there will be some stranded costs arguments and a lot of resistance. But this change is beginning to occur. For example, British Gas is very interested in developing very small-scale combined heat and power projects which go down almost to household level. There is a good deal of friction here. Where the

Lord Birdwood *contd.*]

electricity and combined heat and power plants that we have talked about come in is quite close to the customer. The pool price is about 2.5p. The transfer value to the RECs is about 3.5p. The price to the customer is 7p to 8p. Sixty per cent of the cost is downstream of generation. Therefore, if one has a new system in which there is the ability to locate bio-mass plants in logically sensible places, for example in the west country where a lot of system reinforcement would otherwise have to take place, one can see a very economic network of smaller stations, even if the generating cost is somewhat higher than it would be in a large coal plant or gas plant in Selby. But one is closer to the customer. The cost to the customer is no greater than it would otherwise have been.

211. Have these ideas begun to migrate into the minds of the large generators? One pictures it as being an opportunity on which they can pounce rather than one that they hope will go away?

(*Mr Robinson*) A lot of people realise that this change is taking place and wondering what to do about it. Large companies take a long time to move around, but there are entrepreneurial people coming in who understand it. I mentioned British Gas. British Gas is not a large power generator but it is a large energy generator and can see new technologies taking off in this field. Some of the more entrepreneurial RECs are very active in this field. Companies like Enron and Shell see these opportunities coming forward.

(*Mr Billins*) It is very important to recognise that energy purchased locally from local fuel resources produces a recycling effect within the rural economy which can be quite dramatic. We have run studies on certain power stations where the impact on the local economy of a typical 10mW power station can put an additional £5 million per annum into that economy merely through the purchase of local fuel. People buy the electricity but pay the local grower for the fuel. In that respect it is a virtuous circle and can have a radical effect on rural communities.

212. Do you see the need for a specific energy crop policy coming from our dialogue with Brussels?

(*Mr Robinson*) There are three key factors to get the business going. The first is to have a crop policy where we have a fair crack of the whip compared with traditional agricultural produce. As long as we do not have that the balance is weighted against us. It is very unfortunate that in the last Agenda 2000 negotiations the rug was pulled from under what appeared to be a move in that direction so that energy crops on grassland have been specifically precluded from getting annual support. I find that quite astounding and wrong. Secondly, with a lot of local power stations coming forward—this is not so much Brussels as the United Kingdom—the planning structure must be looked at in a way that gives a reasonable opportunity for these facilities to be developed. As in the wind power business, perhaps with some reason, within the bio-mass electricity business there will be local NIMBYs who can hold things up indefinitely. We do not want top-down Stalinist-type planning but there are ways in which the planning structure can be modernised to take account of the rural requirements of an economic and resource use nature. Thirdly, with the splitting of the RECs from distribution and supply the restructuring of the regulations, which do not at present favour the development of small-scale plants, needs to be dealt with in such a way that there is a fair opportunity for imbedded projects to achieve their full economic value.

Chairman: Thank you very much indeed. We look forward very much to your written evidence. I hope that this session has helped to indicate some of those areas in which the Sub-Committee would be grateful for further assistance.

Lord Middleton: Perhaps that written evidence would also define forest residues.

Examination of Witness

DR STUART CHRISTIE, Manager, Energy Forests, Shell International Renewables, called in and examined.

Chairman

213. Dr Christie, I am sorry that our first session this morning has overrun. That is due to the interest in the subject and not the loquacity of the witnesses. Do you want to say anything by way of introduction; otherwise, we shall crack straight on with the questions, of which I believe you have been given notice?

(*Dr Christie*) To give a brief introduction, I am Stuart Christie and I am responsible for the energy forestry projects within Shell International Renewables.

214. How important do you believe is bio-mass to the future of the United Kingdom energy market?

A. We believe that bio-mass and particularly energy crops are of particular importance and will play a central role in the United Kingdom. We must look at that in the context of what is happening in the European Union with respect to the new White Paper. A 1 per cent share of the electricity requirement means that a substantial area of approximately 150,000 ha of energy crops can be planted in the United Kingdom. But it is important for the energy sector for a number of reasons. Earlier mention was made of the climate change levy. Energy companies look for ways to buy into the renewable energy sector. That is important for the agricultural and forestry sector. I do not think that you can separate marketable energy crops into two. You must look at residues as well as dedicated bio-mass crops together. That is important to both the agricultural as well as forestry sectors, both of which are depressed at the moment. This may provide an opportunity. As a source of renewable energy it is also important to the consumer, because the additional penalties that the consumer must pay for renewable energy from bio-mass and energy crops is not that high; it may be negligible. It is not a different type of energy but something that is tangible. It is also important from the environmental point of view in terms of carbon sequestration. It increases the amount of renewable energy versus fossil fuels. Given a favourable institutional framework for energy crops, the market risk is decreasing because of NFFO-type products. The critical area for the United Kingdom and Europe is feedstock supply, and that is something on which we must concentrate.

Lord Soulsby of Swaffham Prior

215. Let us consider the differences between the United Kingdom and Europe, at which you have already hinted, and between Europe and the rest of the world for bio-mass production and use.

A. We must consider two issues: first, the institutional framework in which we are operating; and, secondly, feedstock type and supply. The institutional framework will govern and drive the feedstock supply. There are lessons to be learnt from Europe. If one takes Finland as an example, CO_2 taxes have been around for a long time. Nineteen per cent of that country's energy (six million tonnes of oil equivalent) comes from renewable resources in the form of forestry residues. In Denmark their Energy 21 policy states that all district heating plants need to be co-fired by 2005; in other words, those small plants must be converted to provide both heat and electricity production. That is somewhat different from the United Kingdom where heat from bio-mass is not as big as it is in the nordic countries. In Germany there is a guaranteed offtake of up to 5 mW of electricity. Therefore, there are a lot of drivers from the market perspective. The Netherlands has a 3 per cent voluntary obligation and also a substantial energy tax. One can also obtain investment subsidies. There is also the emergence of trading in green electricity. If you compare that with the rest of the world where a good deal of my group's experience lies, Europe provides some really choice markets. The needs markets in South America, Central America and Africa are not really interested in renewable energy or whether it is fossil-fuel fired; it is price that is important. The institutional frameworks in those markets to promote the use of renewable energy do not exist. On the feedstock side, for Europe that is of critical importance. An example is what is happening in the Netherlands whose policy is by 2020 to have 10 per cent of its energy from renewable resources. Of that, 5 per cent will be bio-mass. Through both dedicated bio-mass crops and the use of bark and roadside clippings and other agricultural resides they can provide 1 to 1.3 million tonnes. That implies that there will probably be a shortfall of about 2.3 million tonnes per annum of feedstock in that country. A number of other countries in Europe face the same situation. The United Kingdom should closely watch those developments. If that is compared with the rest of the world, one can grow bio-mass in Latin America, probably at double the rate achievable in the United Kingdom. Because of a number of issues such as economies of scale and cheaper resources one can grow it at half the price. These are important considerations.

216. Does it follow that because it is possible to grow bio-mass elsewhere than in Europe at half the price there will always be a need for some subsidy in Europe?

A. It is interesting to draw some parallels with the big sustainable forestry industries in the world where there are very short rotations, sometimes as little as 10 years. For example, Chile has over 4 million hectares of forestry plantations. It began with subsidies in the form of DL701. The Brazilian forestry industry is now approaching 6 million hectares. They all began with subsidies but they do not exist any longer. I believe that within the United Kingdom subsidies or some kind of subvention in future will be required for this to be viable.

217. Do you believe that that will be required on a continuing basis? You do not see us following Chile and Brazil and phasing out support?

A. I believe that that is possible. Over time the playing field will be level and it will be a far more market-driven approach. What interests energy companies is not whether it comes from dedicated sources or residues but the quality and price. Competition will drive down production costs and

Lord Soulsby of Swaffham Prior *contd.*]

also help with the development of technology to improve yield.

Lord Rea

218. Does the support regime for agriculture in Europe get in the way of commercial incentives for technological development of bio-energy?

A. I believe that it does. The current policy with respect to agriculture creates an uneven playing field in the market. Anyone who is involved in growing bio-mass needs to be in a market. That market will then drive the technology side of it.

219. There are moves to change the CAP. Do you believe that that is a move in the right direction to decrease the disincentive?

A. We are watching the changes that are taking place in respect of the Common Agricultural Policy and the climate change levy with a lot of interest. It will help considerably. However, we believe that for it to be successful in the United Kingdom there is a need for some kind of subsidy in the short to medium term—10 years is probably a good measure—which will decrease over time to make the growing of bio-mass viable. Economy of scale is critical in this respect. A critical mass must be developed. Farmers and foresters—I include myself in that—are traditionally conservative and sometimes reluctant to take on new ideas, especially in view of the longer time frames involved in growing these perennial crops. Success breeds success. We need to give examples, not demonstration plots, of commercial areas producing bio-mass and farmers making money for it to take off in this country.

220. There is a need for a large pump-priming exercise in order to achieve lift-off?

A. Yes.

Lord Middleton

221. Referring to forestry as a source of bio-mass, in addition to subvention do you agree that a totally radical reversal of forestry policy in the United Kingdom may help a little? At the moment you have an involvement with the forests of St Kielda and Thetford, but the private grower is not allowed to grow short-rotation crops. If in a wood he has any element of hardwood that he fells he must plant another one which will take at least 150 years to reach maturity. Is not some kind of co-ordination of forestry policy and the production of bio-mass required?

A. I could not agree more. The profile of that issue needs to be raised. A co-ordinated approach to a sustained supply of bio-mass for heat and power generation, whether from the agricultural sector, forestry sector or non-food crop bio-mass sector, is critical at this stage. Linked to that is what we refer to as the grower/processer interface. The combined heat generation project will determine the quality of the fuel. That must be a very close interface at all times with the downstream side of energy production.

Chairman

222. You referred to the potential for improvement in bio-mass at all stages of the value chain. Presumably, this applies anywhere in the world. Can you see United Kingdom bio-mass energy production ever being competitive on world markets?

A. To put it into perspective, the cost of bio-mass production in Latin America ranges between $1.5 to just under $2 per gigajoule. The cost in Europe can range from $3.5 to $7.8 per gigajoule. We have quotations of that kind from the Netherlands, for example. At this stage it is not competitive with the price of production in other parts of the world.

223. What can narrow that gap? It will not be done by technological advances because they can occur wherever it is produced.

A. I believe that the creation of the right institutional framework can narrow the gap. The true cost of power generation from the fossil fuel side can narrow the gap. We believe that carbon emissions, not energy, should be taxed. That could make a significant difference to the market for renewable resources. For example, in Sweden the raw cost of coal is $1.8 per gigajoule. When one puts the taxes on top of it in that country the cost goes up to about $4 per gigajoule.

224. I was not focusing on the gap between this and other sources of energy but the gap between generation from this source of energy where raw materials are produced in the United Kingdom and generation from this source of energy that is produced elsewhere in the world?

A. You are quite correct that the focus in other parts of the world on growing this resource is different. It is easier to grow it but there is no market, or the market is smaller. One cannot avoid the market. Perhaps you would rephrase the question.

225. One envisages that technological advances will narrow the gap between this kind of energy and other sources of energy. However, from the international perspective I am interested in the gap between the cost of production in the United Kingdom and the cost of production in other parts of the world. What can narrow that gap, or will United Kingdom production always be uncompetitive with production elsewhere in the world?

A. A lot of things can be done in the United Kingdom to narrow the gap. If one takes the costs of growing bio-mass in other parts of the world, what are the significant components? One of them is harvesting. Harvesting represents about 50 per cent of the cost. The harvesting technology and the people who use it are well developed. There is at least 20 years of research and development behind it. Therefore, we are able to drive down those costs substantially. The equipment used for harvesting in the United Kingdom is not designed for the United Kingdom. For example, we use harvesters that are designed to operate in snow, such as in Sweden. Harvesting takes place in winter where in many places in the United Kingdom it is mud. Not only does that affect productivity but the sustainability of the site, in that compaction and other factors may cause damage. A lot of emphasis needs to be placed

Chairman *contd.*]

on harvesting. We must also consider other controversial issues. For example, short-rotation coppice focuses on a product of small dimension. The bark to wood ratio is higher than it is in produce of larger size, which means that the ash alkaline content is higher; in other words, the conversion efficiencies can be lower than in pieces of wood where the ratio of bark to wood is higher. Another issue is storage. The density of the types of wood used in the United Kingdom is about 350 kg/m 3 , whereas in Latin America some woods have a density of 500 kg/m 3 to 800 kg·m 3 . That has a huge effect on harvesting and transport. In particular, in the United Kingdom and other parts of Europe the seasonal aspect of the drying and storage of wood is of significance. The lower the density the higher the rates of bio-degradation. A lot of excellent work has been done with respect to poplar and willow technology in the United Kingdom and Europe but there is a need to look at other species and clones to provide much better results. The short answer to the question is that better harvesting, species and yield can narrow the gap.

Lord Rea

226. To transport this higher density and higher calorific value material from other countries 3,000 or 4,000 miles away decreases its competitiveness. Is it in any way sensible to bring bio-mass feedstock from the tropics to Britain?

A. We have had a look at the question of transporting wood in bulk from other parts of the world into Europe. We believe that with some innovation the price in Europe—a European trade in bio-mass is developing—can be competitive. However, one must look at the question of the energy balance and the input/output ratios of transporting a large amount of wood.

Chairman

227. If it was translated into the price of oil it would become quite valuable?

A. It starts to reach break-even. However, technology for the development of bio-fuels is developing at a fairly rapid pace. The value addition to the raw wood through densification, such as pellets and briquettes, is also of interest to us. There are potential methods of bulk transportation of large amounts of bio-mass from other countries in the world.

Lord Nathan

228. Is there any possibility of transporting bio-mass in the form of gas from countries in South America?

A. As far as gasification is concerned, the know-how is there but our costs versus theirs are much higher. However, we are currently working on this.

Lord Marlesford

229. Earlier you said that in Latin America the cost of biomass production was $1.5 to $2. What is the comparable figure for oil based on $16 per barrel?

A. I must pass on that question.

Lord Marlesford: It would be of assistance to have that figure.

Lord Birdwood

230. Effectively, you have already answered the next question that I intended to ask. Are there any other technical or scientific tripwires that you have not so far mentioned?

A. I believe that the focus should be not just on lowering production costs but increasing yield. However, when increasing yield one must consider disease resistance, and in the United Kingdom given the current population and fairly narrow range of planting there is potential for catastrophic disease.

Lord Soulsby of Swaffham Prior

231. What are the dangers of devastating disease, given that with global warming pests can be transmitted from other parts of the world?

A. There is a fairly vigorous trade in this material throughout the world and phyto-sanitary issues are of importance. In some cases quarantine is required depending on the particular climatic conditions. One can mitigate the danger of the spread of disease by planting other crops as an insurance policy, for example eucalyptus.

Earl of Selborne

232. If by 2020 it is hoped that perhaps 10 per cent of energy requirements will be met by renewables, how will the conventional fossil fuel industry respond?

A. I believe that it will respond favourably, particularly in the light of the climate change levy. However, we would have preferred a carbon tax rather than an energy tax. There is also the option of integrating bio-mass plants into fossil fuel power stations. Clean coal technologies and the latest generation of highly efficient natural gas-fired power stations can offer other opportunities. Co-generation at existing plants is an attraction given that the electricity infrastructure—transmission lines and so forth—is already there. Co-firing with wood or liquified fuels or bio-mass is a good way of sharing costs. As to distribution costs, if the power station is very close to the area of bio-mass production transport costs are reduced. I believe that the conventional fossil fuel industry will look favourably on these developments.

233. If one has a series of power stations dotted round the country it may be convenient for bio-mass producers, but what is it that makes those plants attractive in cost terms?

A. If one considers a 140 kW power plant, it takes only three people to operate it. If one considers a much larger plant, for example Cuijk in the Netherlands, the same is true. However, to bid for a

Earl of Selborne *contd.*]

50 mW bio-mass power project would require the same amount of energy as for a 700 mW gas-fired project. You still need the same administrative staff to support that size of project. However, I agree that cost is a challenge that confronts small plants.

Chairman

234. What message do you want to give policymakers to provide incentives in this area?

A. The policy needs to related to both the fossil fuel levy and power generation as a whole. Both existing and new generators should be encouraged to invest in the renewables sector. From the upstream point of view, the policy should be to create a level playing field in the production of energy crops so that they are cost competitive.

Chairman: Dr Christie, thank you very much for your assistance.

TUESDAY 18 MAY 1999

Present:

Birdwood, L.
Hogg, B. (Chairman)
Marlesford, L.
Middleton, L.
Nathan, L.
Porter of Luddenham, L.
Rea, L.
Soulsby of Swaffham Prior, L.
Walton of Detchant, L.

Examination of Witnesses

MR MARTIN FROMENT, Senior Consultant, Leader of Novel Oil Crops Research, DR MIKE BULLARD, Senior Consultant, Leader of Biomass and Fibre Research, DR MARTIN HEATH, Team Manager, and DR JULIAN SOUTH, Consultant, Specialist in Industrial Oats, ADAS, called in and examined.

Chairman

235. Gentlemen, welcome. Thank you for your written evidence and for agreeing to come here to give oral evidence to help the Sub-Committee. Dr Bullard, I believe that you are to take the lead. I ask you to begin by introducing your colleagues. If there is anything that you want to say by way of introduction we will be happy to hear it.

(*Dr Bullard*) I should like briefly to introduce the delegation and make a statement of the position of ADAS on non-food crops. ADAS is an independent consultancy research organisation, formerly a MAFF agency, working in all agricultural, environmental and land-based sectors. We have over 40,000 clients in the United Kingdom and overseas and in excess of £1 million of our work annually is concerned with non-food crops. The delegation here today reflects the technical leaders in different areas of non-food cropping. I work mainly in biomass and fibre crop research and consultancy. Martin Froment is a specialist in novel oil production. Julian South is the industrial cereals expert, and Martin Heath attends today with an overview of ADAS research and consultancy policy. The ADAS position is that there is more potential for non-food cropping in the United Kingdom than ever before. Sufficient land could be diverted towards the production of a very wide range of crops, both high volume/low value commodity species and also low volume/high value niche crops. We will explain these terms later on. ADAS considers that at least 2 million hectares out of a total of 11 million hectares under arable and lowland grassland production could be turned towards non-food cropping with appropriate support and incentives. It is not appropriate to select crops on the basis of opportunities for large volume production only. Non-food cropping is unlikely to be viable without subsidies and enterprises will require support in the medium term. This support is necessary for a number of reasons: it mitigates against the increased risk of undertaking novel ventures; it acknowledges that in most cases there are environmental benefits associated with non-food cropping and it enables technical and market barriers to be overcome. However, support purely focused on crop production through set aside or other grant aid is not appropriate in all circumstances. ADAS considers that this support should be partially de-coupled from existing mechanisms in order to allow greater flexibility to reinforce the weakest element of the production chain. We will give specific examples in later questions. Looking to the future, ADAS considers that there should be two mechanisms for support. De-coupled market development support administered through rural development initiatives will be appropriate for commodity crops where the crop can easily be grown but market or processing technology deficiencies require aid. Alternatively, niche crops should receive support targeted at the grower where there is a high risk of crop failure but the market and processing technologies are well defined. Key to the success of non-food cropping will be strategic R&D that embraces both the producer and processor. There are many examples of this within both the European Union and United Kingdom research programmes. Turning to regulation and international competition, non-food cropping offers opportunities for import substitution and in many cases market domination; existing regulation in many cases hinders the development of markets. Finally, ADAS does not feel that it is appropriate to prioritise the crops that should receive support. They can be assessed only on a case-by-case basis within the context of existing industries. Where there is direct competition for limited support resources life cycle analysis can however play an important role in identifying the relative merits of two potential cropping options. The reconciliation of energy ratio calculations and other measures of environmental impact should be a target for the future.

236. To pick up where you left off, you rightly make the point that it would be foolish to prioritise crops simply in terms of their volume. The focus of this Sub-Committee is the potential for technological change in this area. Therefore, accepting your reluctance to prioritise, where do you see technological change in either production processes or the near market making a difference in the short to medium term?

(*Dr Bullard*) That will differ depending on the market or crop.

(*Dr South*) Perhaps I may refer to industrial oats, although some of our initiatives would apply also to other cereals like wheat and barley. There is no doubt that the oats breeding programme has been very successful. Modern oat varieties exist which offer potential for industrial cropping now. They have a

Chairman *contd.*]

higher oil and protein content. There is also no doubt that GMO technology in the longer term will increase the ability to breed specific oats for industrial cropping, but that is not an essential prerequisite. Present varieties offer significant potential already. There is lack of knowledge regarding the functionality of many of the new cereal components. There must be further research to understand the functionality of those components and also greater understanding of the agronomic and environmental effects of those components. Processing technology already exists to process oats and other cereals for industrial markets, but that requires significant further development. Much of this technology is outside the United Kingdom. There must be initiatives to bring that technology within the United Kingdom and encourage processors to develop such technology.

Lord Marlesford

237. I am not entirely sure for what purpose non-industrial oats are used?

(*Dr South*) Currently, oats are processed in the industrial market into specific high-value oils. Gum fractions are used in cosmetics and the body care market. They are also used in the pet care sector for shampoos and other products. Oat starches are also utilised as cosmetic ingredients and as additives to such products as latex gloves for surgery.

(*Dr Bullard*) With respect to biomass crops, we consider that the technological developments that are available to the United Kingdom industry come very much from the introduction of new high-yielding species and the requirement to persevere and support crops such as miscanthus. There is also now a case for technology to provide imbedded generation rather than power supplied to the national grid. Imbedded generation would allow small-scale cropping of biomass crops on a local or regional basis and direct power supply to the village, town or community. This technology exists in Scandinavia but so far is not utilised in the United Kingdom. There are a number of advances in hemp as we understand more of the potentials for such fibre as a substitute for other building materials, for example fibreboard. We understand better the harvesting and processing requirements and the optimisation of processing of such fibre crops, but there is still a long way to go fully to exploit our understanding of how this crop can be manipulated for other uses.

238. The Government's target for biomass is 125,000 ha by 2010. If my arithmetic is right and your 30 mW power station comes from 16,500 ha, that makes 227 mW in total to be generated by biomass.

(*Dr Bullard*) Yes.

239. How important is that in relation to national requirements?

(*Dr Bullard*) The United Kingdom's annual energy demand is approximately 60 gW. If we work on the basis that by 2010 10 per cent of that demand will be met by renewables we are looking at 6 GW from renewables. Therefore, 125,000 ha will provide a small but significant proportion of that requirement. The 125,000 ha is by no means an upper limit for the opportunities for generation from biomass.

240. Who produced the target of 25,000 ha?

(*Dr Bullard*) It was produced by MAFF in association with the DTI towards meeting the Government's objectives on CO_2 mitigation and renewable energy generation.

241. It is an important target. I just wonder how it has been worked out.

(*Dr Bullard*) It is based on what technologies are likely to be in place in the medium term. Hydro-electric and wind power will undoubtedly produce most of our renewable electricity in the next five to 10 years. The expectation is that biomass in terms of both crops grown specifically for that use and also forestry and agricultural wastes will meet most of the deficit.

242. Is the 125,000 ha based on what it would be nice to produce towards the target or what it is likely to be possible to persuade people to do?

(*Dr Bullard*) I suspect that it is a hybrid of the amount of money available to be funnelled at the time into supporting crop production with a view to reaching the overall goal to which we strive and the DTI's expectation of how much wind and hydro-electric can contribute to that target.

Lord Marlesford: It would be very helpful if we could have a note from MAFF/DTI on the methodology used to reach the target.

Lord Porter of Luddenham

243. We are talking here about gigawatts of energy. Is this consistently free energy in the form of electricity? You have mentioned the burning of fossil fuel. Does it include heat energy which would be four times as much?

(*Dr Bullard*) In many instances the power stations now being built to burn straw and coppice have guaranteed supply contracts for their electricity. The heat that is produced is very much a wasted commodity under the current structure of the NFFO. Therefore, the power produced gets added value if it can be used to heat glasshouses or provide heating to local communities, but that is not enshrined within contracts. If we took on board imbedded generation as in Scandinavia it would provide an opportunity to use that heat.

244. But when you talk about gigawatts per hectare for coppice does that include the heat or just the free energy?

(*Dr Bullard*) That is just the electricity, based on a conversion efficiency of 20 to 25 per cent.

245. It does not include the heat that is generated?

(*Dr Bullard*) No.

Lord Middleton

246. Referring to cereals for industrial use, from the point of view of the farmer it is very easy for him to switch his output of cereals. Does the demand and processing capacity exist to allow that kind of switch, which could very easily happen, to take place?

Lord Middleton *contd.*]

(*Dr South*) That is a very good question. At the moment, what the market needs is a pull from industry. If you look at other European countries such as France there is a significant pull from within the chemical industry to utilise cereals. We in the United Kingdom have the supply base but we do not have the pull or the inspiration within the chemical industry that other European countries have. It is very much market pull that is required.

Chairman

247. I want to be clear as to what you say about support in the medium term. Are you saying that what is required is start-up support to establish markets and encourage production? You appeared to say that in the medium term these crops would need support regimes to be viable. Why should we spend money on that? I can see that in the renewables field we may have a policy objective that justifies support, but why should we spend money on these other crops?

(*Dr Bullard*) Support would acknowledge the risks involved in moving over to these crops.

248. But there are risks in all businesses?

(*Dr Bullard*) Indeed. However, it would acknowledge at the same time that the environmental benefits associated with diversifying into other crops either because of the products that they produce and the opportunity for them to replace chemical-based products or other more environmentally damaging products or the downstream biodiversity and ecological benefits from a certain cropping regime would need to be enshrined in some level of support to allow the farmer to make a reasonable living from crops that are more environmentally benign and beneficial.

249. You say that in the medium term they would not be viable without such support?

(*Dr Bullard*) In many cases that is correct.

Lord Marlesford

250. I want to get a feel for the viability of these crops. In the very interesting table on page 28 there is a column labelled "Net margin". I am not clear what this means. Does it mean the margin to farmers? The figures are rather surprising. For example, for farmers normally winter oilseed rape is more profitable than spring oilseed rape and sugar beet in general is more profitable.

(*Dr Bullard*) These are net margins expressed relative to the net margin one would expect from over-wintering or natural regeneration set aside. These are not direct comparisons of the market value of the particular crops one against the other; they are relative to natural regeneration. The purpose of this table is not to provide a prioritised list of non-food crops but rather to give an illustration of how one may begin to audit these crops environmentally. The net margin of our operation is the margin over variable and operating costs, i.e. it expresses the margin of an enterprise without considering the fixed costs (e.g. rent) which can be extremely variable and distort comparisons.

251. But if they are all relative to the same thing does it not make them relative to each other?

(*Dr Bullard*) Yes.

252. Therefore, I am surprised by the ratios?

(*Dr Bullard*) Which particular ones?

253. I am referring to winter oilseed rape versus spring oilseed rape, wheat and potatoes, which is a very speculative crop. As a farmer this does not make immediate sense to me if it is meant to indicate relative profitability and if we are considering, in my original question, what will be a viable crop for the farmer to grow.

(*Dr Bullard*) In the context of potatoes, as an example, we are not considering food consumption but that crop grown on set aside for starch production.

254. At the top it says "Food and Non-Food Crops".

(*Dr Bullard*) Yes.

Chairman

255. Is the same true of wheat in this table? Would that also be non-food for this purpose?

(*Dr Bullard*) Indeed.

Lord Marlesford

256. Therefore, "Food" at the top should be deleted?

(*Dr Heath*) With respect, these are food and non-food crops for non-food purposes. Perhaps we should provide an amended copy of the table.

257. What will it pay the farmer to grow these non-food crops compared with what he can make out of growing food crops, because that is what it is all about?

(*Dr Bullard*) Yes. We are approaching it from perhaps a slightly different perspective. The support appropriate for non-food crops must be sufficient to allow them to compete at least with food production, for example cereals. Let us take the specific example of hemp. At the moment, a farmer would be lucky to produce 5 tonnes of retted baled hemp for the processor at a price of £50 per tonne. On top of that he must pay Home Office licences of £400 or so and he has various inputs to pay for. He cannot compete against wheat crops even if they are simply commanding £75 per tonne, which is perhaps the lowest expectation. If we are to have a diversified cropping environment, acknowledging all the environmental benefits that flow from this, then that hemp-producing activity needs some form of buffer to allow it to give an economic return to the farmer relative to a cereal crop.

Chairman

258. Do the calculations in the table on page 28 have imbedded within them the existing support regimes, or do they assume no support?

(*Dr Bullard*) They assume no support.

Lord Birdwood

259. In my opinion, this is one of those cases in which the table will gather authority as time goes on and inevitably it will be used in evidence and quoted hither and yonder. I do not understand which of the categories at the top have a subjective judgmental component and which are objectively measurable?

(*Dr Bullard*) They have all been objectively measured in terms of nitrates in water and the quantity of nitrate anticipated to be captured from run-off from a crop of, say, potatoes or wheat relative to that expected from natural regeneration set aside. They are a quantified strata and the crop would fall into one of the five categories.

260. Therefore, your control is always set aside?

(*Dr Bullard*) That is correct.

Lord Nathan

261. You have been comparing the production of these crops with wheat and so forth. As a non-farmer, you are comparing a crop grown on good land such as wheat with these products. We were told earlier that hemp would grow on almost any soil anywhere. That may have been just a promotion but it was jolly good. Take hemp and flax which we were told would grow on almost any land. I see the hill farmer with very thin soil suitable for grazing sheep in the middle of nowhere growing vast forests of hemp. I question your point about comparing the production of hemp with wheat. You are comparing the production of hemp on good land, whereas we were told that that was not necessary.

(*Dr Bullard*) The majority of the 5,000 acres of hemp currently in production is grown on good arable land, not on hillsides. As a generalisation, the fertilizer inputs for flax and hemp will be less than for cereals, but that is not to say that there is not a yield advantage in applying nitrogen to hemp. The requirement for most soils is 75 to 100 kilos of nitrogen to give peak yields. One cannot escape from the fact that regardless of the end product, whether it is being grown for an environmental reason or purely commercial reasons, farmers will attempt to get the highest yield from the crop that he grows, so there will be a fertilizer input.

262. That does not quite answer my question. If one has very poor land that cannot possibly bear wheat but may bear the grazing of sheep, which are not doing very well at the moment, there may be an economic advantage in growing hemp. I should make it clear that I speak as a non-farmer. I have no expertise in this area. But from what we were told I understood that hemp could be grown economically on poor land such as hill farms compared with land used for wheat production. If that is nonsense I am sorry.

(*Dr Bullard*) My feeling is that specifically in the case of hemp that is not the case.

(*Dr South*) If one takes oats, they can be grown on more marginal land. That is a crop which is very adept at scavenging nutrients from poor soils. It certainly would not have application across all landscapes. It is also true that those areas of the country which turn in the highest yields are not necessarily those which can turn in best quality in terms of industrial processing. There may be opportunities for some cereals for industrial uses, for example oats, in more marginal areas. That is why we are currently involved in a project in the Marches region.

Lord Walton of Detchant

263. The third question that you have been invited to consider is referred to in some detail in your excellent paper. Perhaps you would highlight the technological developments in growing or processing non-food crops which would be necessary to make particular non-food crops viable? Before you answer that question, a couple of days ago I was sent an interesting short paper by a colleague in Oxford which referred to the problems that had arisen through the activities of certain flax beetles in Oxfordshire. Those insects had damaged not only flax but potentially linseed. We have talked about genetic modification. I express some regret at the fact that some of my former colleagues in the BMA issued the report which appeared yesterday. Having said that, are these beetles a problem and, if so, can genetic modification make the crops resistant to them?

(*Mr Froment*) The flax flea beetle as it is known is a problem in linseed and flax and it can be effectively controlled by chemical seed treatment. It is however a good example of how, when a crop like linseed is introduced into the United Kingdom and is grown more widely, a new pest problem emerges. In terms of technology we have been able to overcome that without the use of genetic modification.

264. But if people question the use of these particular chemicals is genetic modification an alternative possibility?

(*Mr Froment*) I doubt very much whether it would be economically justified in linseed.

265. Which particular crops do you think will be made viable by technological developments in growing and processing?

(*Mr Froment*) Perhaps I may give the example of some work in which I have been involved on *calendula* commonly known as the pot marigold. In reality it is almost a garden plant but the seed that it produces contains a C18:3 fatty acid with some unique properties that gives it a role in the paint and varnish industry. It has a very high market value, perhaps four times that of soya. In a situation where there is a plant that is not established as a crop we have a considerable amount of agronomic research to do to bring it up to a level where it can compete effectively against mainstream crops which have benefited from 50 to 100 years of continuous research and improvement. We must also deal with other issues, in this case processing. The plant produces a different seed type and requires considerable investment in finding the correct way to process it to produce an oil of the right specification that can compete effectively in the market.

266. My final question relates to your table on page 21. I am interested to read that financial support for oilseed rape and linseed is likely to decline with the revision of the common agricultural policy. Recently, I read in the *New Scientist* that the Canadians had produced a type of oilseed rape called

Lord Walton of Detchant *contd.*]

Smart Canola which was herbicide and pesticide-resistant as a result of selective breeding, not genetic modification. In which particular category would this fall? Is it high or low in erucic acid?

(*Mr Froment*) I am not familiar with that particular line but I would guess that it is low.

Lord Rea

267. We have touched on the issue of support referred to in Q4. ADAS is the right body to look at this across the board. How successful and well co-ordinated are the present United Kingdom and European Union programmes that support these developments? Is the situation here better or worse than on the continent?

(*Dr Bullard*) Once again, one can illustrate this with specific examples. Obviously, there are a number of support mechanisms. If one takes set aside payments as the starting point of support for these developments, undoubtedly they have provided encouragement for the diversification and regrowing of a number of species on land which would not previously have been used for these crops. However, in many instances one may consider whether targeting support purely at the grower is the most appropriate and rapid way of stimulating and developing the market for the production of crops such as hemp. If we look at more specific examples, energy cropping is supported mainly through the NFFO. This pays a premium price to the energy producer for the electricity that goes into the national grid, but it is a very competitive process. The best bid for biomass generation is likely to receive funding regardless of its technical superiority. In essence, that cascades the pressure on the farmer in terms of the margins and value of the product that he is paid, so it is not necessarily the most effective mechanism for supporting or encouraging widescale biomass cropping in the United Kingdom. There have been some very positive developments with project ARBRE and additional payments on a regional basis to support the growing of the crop in a 50-mile radius of the power station. ADAS very much hopes that that scheme will be expanded to cover other areas of the country as power stations are proposed.

Lord Marlesford

268. Who makes these additional payments?

(*Dr Bullard*) The additional payment is made by the Ministry of Agriculture and effectively tops up the farm woodland grant scheme to a total value of £1,000 per hectare. It is anticipated that that covers half the establishment costs of short-rotation coppice. In so doing it mitigates the risk to the farmer of having to tie himself into a 15-year agreement with a power station and the opportunity costs that he may have lost by not being able to exploit that land in more profitable ways in future should they arise. That is the kind of stimulus we need to encourage biomass and CO_2 mitigating crops.

269. Do you think that that figure will be adequate for the purpose?

(*Dr Bullard*) So far it appears that it is, and farmers are signing up on that basis. The process that ARBRE has in place for harvesting the crop and paying the farmer £20 per tonne for that material should be sufficient for it to be a viable economic activity for farmers.

Lord Rea

270. Is the help that is offered at the moment too *ad hoc* and piecemeal rather than one that takes a wider look at developments in the whole non-food crop area?

(*Dr Bullard*) We advocate that support both for large volume/low value commodity crops such as biomass, fibres and industrial oats and equally for the high value/low volume niche crops can be better focused at the more appropriate point in the production chain which currently limits exploitation of the crops.

271. Can you say something about how European support systems impinge on non-food crop production? Some good ideas are being adopted in Europe and perhaps we should follow them.

(*Dr Bullard*) To give an example of where European Union policies impinge, there is a requirement for hemp crop to have set seed before it is harvested. This mechanism is put in place purely to ensure that the farmer grows the crop for a commercial purpose rather than simply for subsidy. It must be seen that the crop is in the ground rather than that it is ploughed in in July to get a seed bed prepared for another species. Because of the way in which the hemp plant grows very early flowering varieties must be planted to enable seed set to occur in the United Kingdom. As soon as the hemp plant flowers it stops producing extra fibre. Currently, the United Kingdom produces an average yield of, say, five tonnes of fibre per hectare compared with Italian production of eight to 10 tonnes. That directly limits the competitiveness of United Kingdom fibre production.

(*Dr South*) As to oats, currently there is enough support to growers. All that discourages oat growers is the lack of a suitable market for their product. The heavy support for wheat and, to some extent, barley has created a problem in the sense that certain money has been directed to wheat and barley but oats receive very little in terms of research money and continue to be regarded as a minor crop that does not justify support. The production systems are in place but it is the market which limits further developments.

Chairman

272. Perhaps I may press you a little further on the idea of greater focus in support regimes. I am not quite sure how that answer matches with what you said earlier about ADAS not prioritising or picking particular crops.

(*Dr Bullard*) I am not prioritising in the sense that it would be impossible to determine from this position whether support for an extra 1,000 ha of evening primrose was a viable proposition. That would depend on how much evening primrose was currently produced. The evening primrose market is pretty much totally covered in the United Kingdom.

Chairman *contd.*]

But that is not to say that evening primrose is not a viable alternative crop. That is perhaps where our reluctance to prioritise comes from. It can be determined on a market-by-market basis.

273. What are you advocating in terms of focus?

(*Dr Bullard*) The focus of support should not be directed uniquely to the crop in the ground but through rural development initiatives or replacement for structural funds on a regional or possibly national basis. Support should be focused at the correct point in the production chain.

274. What is the correct point?

(*Dr Bullard*) That will vary from crop to crop. To complicate the issue, one example is biomass where we need support at both the growing and processing point. I suggest that in the case of hemp support should be very much targeted on the processor, which in the case of the United Kingdom would be Hemcore at the moment. Equally, I advocate that for the most rapid and expansive development of fibre markets the monopoly situation that exists at the moment should be discouraged.

(*Dr Heath*) Whereas at present the support is focused largely on two aspects of area aid and yield, with non-food crops the likely support structures will be more complex and varied in relation to the nature of the crops.

Lord Rea

275. Are there examples in Europe where the support is further down the line towards the processing of the product rather than its production?

(*Dr South*) I am not aware of any financial support in that sense, but certainly in Scandinavia a lot more support is given to research initiatives in order to set up the infrastructure to utilise the new markets. In particular, Finland has just undertaken a five-year programme in barley and oats. That will put that country well ahead of anybody else in Europe in that market.

276. Referring to the table on page 28, the final column is headed "Energy ratio". In a number of cases there are blanks. One of those relates to sugar beet. I find that surprising because although it is more costly to produce that crop than other forms of energy the production of alcohol from it creates a good deal of energy. Does it mean that research has not been done in this area?

(*Dr Bullard*) To some extent in preparing the report we are a hostage to the document that is quoted from, Spink & Britt in 1997. Of course, there is an energy ratio for sugar beet but it simply was not in any document that I quoted. To cover liquid fuels from ethanol from sugar beet or oilseed rape, normally one would expect a positive energy ratio of about five or six for liquid bio fuels as compared with a positive ratio of 30 to 32 for solid bio-fuels. It is predominantly for that reason that in the field of energy generation the DTI and MAFF have focused on solid bio-fuel direct to the national grid.

Lord Soulsby of Swaffham Prior

277. Let us turn to regulation. Your document provides a very good overview. To what extent do either United Kingdom or European Union regulations restrict or encourage—if regulations can encourage—the development of non-food crops in the United Kingdom?

(*Dr Bullard*) In some cases they are supportive and in others restrictive. I have already mentioned hemp as an example.

(*Dr South*) The incentives for growing wheat and barley discourage funding bodies such as the Home Grown Cereals Authority or our own Government to support research into minor crops such as oats. Public mistrust of GMOs is also an area that can in the longer term discourage companies from undertaking research into cereals which can benefit in the longer-term from GMO technology. That may force those companies to go abroad. For example, France has a very active wheat-breeding programme.

278. Effectively, you bring that to our attention on page 14 in paragraph 5.2.4 with respect to oats. Is that just an example, or are oats more liable to suffer from public disgust of GMO?

(*Dr South*) At the moment, there are no genetically-modified oats. Many oat breeders see this as an opportunity rather than as a threat, in the sense that the mistrust in the public of GMOs may offer opportunities for oats whereas wheat may not have such an opportunity because it has gone down the GMO route. But in the longer run the opportunities to utilise genetic technology to modify oats to produce additional oil and other components is considerable.

279. Apart from the cultivation of the crops, are there any regulations that inhibit the distribution and marketing of these products?

(*Dr South*) Currently, there are no regulations which prohibit extraction and distribution in the markets that we are investigating. Some of these markets in North America are already being exploited. There are companies which are looking closer to Europe to move their processing technology. There are no regulatory barriers in that sense.

Lord Walton of Detchant

280. But your paper referred to a shortage of proper facilities for the processing of oats as a non-food crop in the United Kingdom. What can be done about that?

(*Dr South*) Currently, there is no facility for processing oats in the United Kingdom unless one looks to companies that have the technology to process other materials. Some of the markets that could be served specifically by oats would require new technology. Existing technology would not be satisfactory for this purpose.

Chairman

281. But there is no regulatory barrier in place?

(*Dr South*) No. There is under way a project entitled Oatec funded under Objective 5b. That is

Chairman *contd.*]

aimed specifically at the encouragement of that kind of processing by the development and demonstration of viable markets.

Lord Soulsby of Swaffham Prior

282. Can these new varieties of oats be used for horse fodder?

(*Dr South*) Yes. The new oat varieties are very high in oil and protein. There are equally attractive markets in the animal feed sector. Currently, there is an initiative to bring together a project under the new European Union Fifth Framework programme to look at the opportunities within the feeds sector. In many ways this would be essential also for industrial processing. This would provide an opportunity for an alternative market. Where oats did not make the grade for industrial processing they could be sold into the animal feeds sector. The new oats are equally valuable in the feed sector.

283. Referring to international competition, do United Kingdom farmers have any advantage over either their European Union competitors or worldwide in growing non-food crops?

(*Mr Froment*) If we look at the United Kingdom's normal temperate climate agronomically it is better suited to crops like oilseed rape and linseed. The latter is a very good example of that. The United Kingdom is the largest producer of linseed in the European Union and it is able to grow it more competitively than its competitors. Since the mid-1980s the area of the crop has expanded, albeit with subsidies provided to the producer. This has resulted in an increase in the crop area, which is now about 80,000 ha. That has led to add-on activity in the crushing and refining sectors in the United Kingdom. Linseed has moved from being a niche crop to a mainstream crop. With Agenda 2000 we expect that by 2002 most industrial linseed will disappear from the United Kingdom. The almost certain consequence of this is that Canadian linseed will be landed at Rotterdam and that seed will be trans-shipped to the United Kingdom. That will have a knock-on effect because of the competitive advantage of the United Kingdom versus European Union producers. That trans-shipment cost will make us uncompetitive and we will probably see a decline in production.

Chairman

284. Is the Canadian crop supported?

(*Mr Froment*) It is not supported to the same extent as European Union crops. The Canadians dominate world production. About 30 per cent of crop production is Canadian production compared with 8 per cent for the EU.

285. So, we are not competitive with Canada in the production of this crop?

(*Mr Froment*) No.

Lord Soulsby of Swaffham Prior

286. To return to the subject of niche crops, one tends to relegate them to a minor market by calling them "niche". It seems to me that that area can be expanded very considerably. Is it possible to expand it in this country so that it forms a major part of non-food crop production?

(*Mr Froment*) There is scope for some niche crops. Reference has been made to the *calendula* crop. That is a high value crop where the price is perhaps up to $2,000 per tonne. However, the area of production within the European Union is probably restricted to no more than 10,000 ha, but potentially that is a profitable crop that can be grown without subsidy.

287. But presumably there would be room for expansion if the market was there?

(*Mr Froment*) If the market was there, yes. The main target for this oil is paints. As we try to reduce the amount of solvents and volatile organic compounds in paints that market will increase. If this oil can be produced in sufficient quantities of the right quality markets will open and expand.

Lord Birdwood

288. What particular environmental or ecological advantages or disadvantages do non-food crops provide? Perhaps the answers can be semi-anecdotal. I suggest a sentence or two in some of the following areas: atmospheric air quality, including odour; soil degradation; the potential for soil decontamination; wildlife support; the enrichment of biodiversity; visual considerations; and possibly the public perception of these crops, as opposed to the historic public view of more conventional cereals and other crops?

(*Dr Bullard*) Perhaps I may kick off with the issue of atmospheric air quality. It is pretty well understood now that burning solid bio-fuels offers the best route for long-term CO_2 mitigation. So long as you have a crop still in the field re-absorbing any of the carbon dioxide that you create in generating electricity then it is pretty much carbon neutral. In addition one is looking at improvements in sulphur dioxide and nitrous oxide emissions in the order of five or six fold by burning biomass as compared with fossil fuels. The positive benefits in those areas are quite clear cut. Potential negative effects may be the visual aspects of large blocks of very tall crops: seven metres of coppice or three or four metres of perennial grasses. I am not aware of any research so far to indicate any particular negative public attitude in response to these issues, other than that people very close to power stations worry about flue emissions. As to wildlife support, key to one of the advantages of non-food crops is that many of them will be spring sown and there will be an opportunity to create over-winter stubble which has been demonstrated to increase the wildlife amenity value of cereal-growing land. That is one example of where wildlife support is expected to increase. As to land decontamination, biomass gives the opportunity with perennial crops to remediate contaminated soils. They would preferentially take up heavy metals like cadmium and arsenic. Similarly, ADAS is now working with a number of landfill companies to identify the degree to

Lord Birdwood *contd.*]

which landfill leachate can in effect be mopped up by these perennial crops which can pass on a benefit in terms of yield to power stations.

289. What about the enrichment of biodiversity? Has your research thrown up anything that suddenly is particularly beneficial for the lark or other species?

(*Dr Bullard*) For example, the biodiversity value of short-rotation willow is second only to the oak tree in terms of the birds and insects that are monitored.

Lord Marlesford

290. Am I right in thinking that set aside is a fairly crucial part of the equation for non-food crops; in other words, non-food crops grown on set aside land can get the set aside payment, and if it is set aside and has nothing growing on it it will receive less remuneration? Therefore, the extent to which there is a requirement that 10 per cent of set aside be used for non-food crops may well be conditioned by the level of set aside in both area and set aside payment?

(*Dr Bullard*) I think you are right.

291. That is a fairly major determining factor. Once one moves beyond the minimum area required for set aside the non-food crop enters a different form of competition?

(*Dr Bullard*) Yes. There are examples where crops are not eligible for set aside and may still have industrial applications. *Calendula* is a nice example of a crop that keeps on appearing and disappearing from the eligible crop list for set aside. If they are not eligible then their viability compared with other mainstream crops and non-food crops diminishes.

292. Presumably, the most important commodity is oilseed rape in terms of the use of set aside?

(*Dr Bullard*) In terms of area, yes.

Lord Middleton

293. I want to return to the question of focusing support. It is clear that farmers will not grow a crop for non-food use if there is not a processing plant handy. On the other hand, processors will not risk making a huge investment in a plant if the supply situation is dodgy. Do you say that support should be focused on taking the risk away from the processors and, if so, where is the money to come from?

(*Dr Bullard*) The support in those instances should be placed with the processor where the constraints in supply are not overwhelming. To take hemp, almost any farmer can grow it and provide a processor with a reasonable yield. The problem lies in the exploitation of the market and developing a processing capability to produce the end products. Support should be focused on the producer of the products. For example, with a crop like borage one may have total yield failure in some years but good yields in others which are very profitable to the farmer. That support should perhaps be focused more on the grower to mitigate the risk of variable yield predictions.

Chairman: Thank you very much indeed for coming to give evidence. If there is any further evidence that you want to provide to us we should be grateful to receive it.

Examination of Witness

PROFESSOR CHRISTOPHER J LEAVER, FRS, FRSE, Head of Department of Plant Sciences, University of Oxford, called in and examined.

Chairman

294. Professor Leaver, welcome. We have not prepared any questions to put to you. I invite you to share with us your thoughts on some of these issues. A number of members of the Sub-Committee have heard them already but others, including myself, have not. If you will forgive us, we will interrupt you very rudely to pick up various points. If you prepare yourself for the interjection of these missiles and do not take that ill I would be most grateful.

(*Professor Leaver*) I come before the Sub-Committee as an academic scientist who teaches, researches and collaborates, as encouraged by current and previous governments, with industry. I was also involved in writing or contributing to just about all the statements that have been made by the Royal Society on genetically modified crops and scientific advice in that area, more recently the one that we have prepared for you. Not having been to one of these sessions before I was unsure what you wanted. Without being rude, it may help if I give a quick tutorial on what may be possible from the scientific point of view.

295. That would be excellent.

A. I start from the premise that the only renewable source of energy is the sun and green plants are the only organisms on earth that are capable of capturing that energy, as Lord Porter well knows. Together with CO_2, water and a few minerals those plants convert the energy derived from sunlight into the bio-polymers which sustain us in terms of food and all the other things that we are talking about. You will also be aware that we are dependent on fossil fuels which historically also came from plants and that it is a finite resource. It is also a source which is potentially polluting. Many of the products from petroleum and gas-based feedstocks to which we have grown accustomed are often not recyclable. Manmade products from petroleum-based feedstocks are very often not recyclable and we have problems in getting rid of them when we have finished with them. One has only to look at plastics and landfill sites to be aware of that. On the other hand, plants take CO_2 and water and convert them into polymers which on the whole are designed for recycling. When a plant dies it is rapidly degraded by soil micro-organisms and serves as sustenance for other organisms in the eco-system. The three basic products that plant make are: carbohydrate-based polymers such as starches, which no doubt you have heard about; aminoacid-based protein polymers; and also fatty-acid-based polymers, such as oils. All of these have food and other uses. Many of them have a whole variety of uses which for economic reasons we have not yet exploited because it is cheaper to use petroleum-based feedstock to do it and the technology for that has already been developed. I argue that plants have the potential to be bio-refineries. If we understand the basic genetics,

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biochemistry and metabolism which goes on in plants and related organisms we may be able to use plants as bio-refineries which are much more cost-effective or can produce products that we can substitute for those derived from petroleum-based feedstocks. We have moved away from nuclear power which in any case will not produce the kind of polymers that we require in our society. On the other hand, the potential for bio-fuels and bio-products is there; it is being utilised in certain countries in South America to replace some of the petroleum-based feedstocks with things like gasahol.

Plants make of the order of 100,000 chemicals. A lot of the original and current pharmaceutical products were and are derived from plants. People have now found way of engineering the production of these into microorganisms. Something like 25 per cent of the top 20 pharmaceuticals by price in the world are made by the genetic engineering of micro-organisms grown in fermenters. In the longer term the potential exists to make a whole range of pharmaceuticals including vaccines, possibly antibodies and even blood products, from plants. This is a long way down the line. That is high value. Given our background in research and experience, this may well do something for us. Humanity has been very good at finding uses for things once they have been discovered. Given the array of plants and the chemicals that they produce, there may have many undreamt of uses. What we have been quite good at doing, albeit at a low level of investment in this country, is understanding basic genetics and biochemistry and trying to find ways to modify the activity of the enzymes which make these polymers and other products more suitable to our end use. What do I mean? There has been little intervention in terms of genetic modification of crop plants until recently. I am not necessarily an advocate of the technology but if I see an added advantage then I see advantages over conventional plant breeding. Conventional plant breeding has produced a lot of starches, proteins and fatty acids that we can use. You have been talking about crops such as linseed. There are a whole range of crops that we cannot grow in this country. Realistically, the United Kingdom grows two or three crops: wheat, barley and oilseed rape, the last one being a recent introduction. There are a lot of other crops which produce products that we want but which grow elsewhere in the world. They are probably 99 per cent similar to the crops that we can grow in this country in terms of metabolism. By understanding these crops by virtue of the enzymes and metabolic pathways that they contain it will be possible to identify the relevant genes and subtly modify the metabolism of existing crop plants in the United Kingdom by generic transformation. I cannot talk about the economics of this and the distortion by the common agricultural policy. No doubt that discussion will be had elsewhere. But there are opportunities, if not for growing things in this country, then at least for developing the technology and industry to allow this to be applied elsewhere in the world. One thing which I find frustrating is that we are a small offshore island which basically has few natural resources except our innate intelligence and hopefully an ability for hard and sustained work, coupled with a good education system. We also have the capability to take raw materials from elsewhere and, with the necessary know-how, to fabricate them, add value and re-export them. What concerns me about recent debates on GM is that we have put in a significant investment, but our major competitors are the Americans and Japanese who have been very successful. In terms of biotechnology start-up companies who seek to modify plants for non-food use the States are world leaders.

296. Is what you are saying, therefore, that we should be focusing on scientific innovation rather than land use? From what you say, land use for non-food crops will not be significant.

A. I heard an interesting figure the other night. Forty per cent of the United States, 18 per cent of Canada and 75 per cent of the United Kingdom is farmed. We are pretty short of land. The type of land that we have is very different from the prairies in the States. It may be that there will be some non-food uses for very high value products for oils or pharmaceuticals. I cannot do the sums. These things will certainly be grown in relatively small amounts. It is unlikely that we will be able to grow many crops other than those which we grow now. Just now reference was made to marigolds, which is one option. That will be small volume. You will be aware that companies like Astra-Zeneca are making heavy investment in wheat improvement not just for food uses but to produce starches with many properties having many uses, for example paper coatings, plastics and so on. They are investing £50 million in the John Innes Institute to build a lab to reduce this work to practice based on basic science carried out by that institute which is supported by the BBSRC. My impression is that that company will export that know-how worldwide. It is often more appropriate to grow these plants in other parts of the world. I heard mention of the efficiency of growing certain crops, for example hemp, in Italy and elsewhere. We are part of Europe. It may be that certain crops within the European Union will be grown in some countries and we will grow others. That may make sense. It may be that eventually the politicians and bureaucrats who control these things will get the balance right. I do not know. Another factor which you will have heard about—but may not know much about—is that many organisms often produce products which we know little about. The other night I gave the example of a bio-polymer which has many of the characteristics of polypropylene, polyethylene and that type of thing. Basically, it is a plastic. Currently, it is synthesised naturally by soil bacteria—I can give the names if you wish to have them—and basically this plastic is a storage product, rather like starch stores products from photosynthesis in plants. About 95 per cent of the dry weight of many soil bacteria store this"plastic" and when they need to they digest it and re-utilise it. These compounds called PHAs and PHBs have many different useful characteristics. Interestingly, one can take two enzymes from the bacterium introduce them into plants by generic engineering and target them to the chloroplasts which captures the light energy. The plants then yield quite high levels of biodegradable plastics in laboratory situations. Currently, these plastics are made in

bacterial ferment cultures initially developed by Zeneca but now sold on to the Americans. The biodegradable plastic product is used in everything from surgical implants, stitches, through to biodegradable plastics for containers for medicines and disposable razors in Japan. The good news is that it can be recycled. Therefore, it has all the benefits of restoring carbon balance in the atmosphere. This is only just the beginning; we have scratched the surface. Knowing man's ingenuity, I am sure that we can find out a lot more, but plant science on the whole in this country in certain molecular and biochemical aspects has been, as you would expect, relatively under-funded. The avenues of exploitation have been rather limited. Our American competitors have been somewhat more successful than us.

297. To pick up where you finished, why is the exploitation of some of this technology not happening?

A. It is happening but slowly. Obviously, public perception and the recent media frenzy, of which you are all aware, which caught a lot of scientists unprepared has not helped. A document was produced by the Royal Society on this topic last September. I believe that it was fairly well balanced. We scientists must take some of the blame for not sharing our understanding with the media and journalists so they can transmit this information to the public. We have been hijacked by non-representative groups of activists. Progress is a good thing and it should be encouraged, but equally one must put in place the checks, balances and assessments. One should take equal responsibility for encouraging or stopping progress. I argue that those who are anti the use of modern gene technology which has done a lot for us—I argue that it is an extension of normal plant breeding—must take responsibility for this. A number of us would not be sitting here without many of the initial advances which were shown to have down sides. Most of the chemicals and pharmaceuticals that we use are differential poisons; they poison one part of us, the cancer cells or bacteria, before they kill the rest of us. We have learnt how to use those and live with the risks. The same applies to any technology, which means that a cost benefit analysis is required.

Lord Nathan

298. I heard you the other night with fascination. One of the things that you mentioned right at the beginning of your address was the technique of breeding and that involved the introduction of a different gene into the subject plant.

A. I believe that I was talking about conventional plant breeding which takes two closely related plants that both contain approximately the same number of genes. Let us take the figure of 30,000. When you combine them you end up with a hybrid that contains the same number of genes as the parents but 15,000 will come from one and 15,000 from the other. That is also genetic engineering. But the plant breeder who makes the initial cross must then select from the population from those two parents those with the characteristics that he or she wants. It may be bigger, better or more disease-resistant plant. The breeding process goes on and on so that in the end one ends up with the best characteristics of the best line that one starts with and the new characteristics that one wants to introduce. That may take eight to 14 years and it is fairly imprecise. One may well introduce genes that one does not want. With modern technology one can isolate genes by a variety of methods and completely characterise them and understand what they do. One then takes that gene which may confer resistance to a pest or a gene which includes an enzyme that modifies the starch content. For example, we took a single gene coding for an enzyme involved in respiration in plants and decreased the amount of the enzyme by about 50 per cent in potatoes. To our surprise, the amount of the starch in potatoes went up by about 50 to 100 per cent. The benefits of that are quite significant. I take that as an example of where a single gene is taken of known sequence. One can control it very precisely in terms of when it is switched on and off and where in the plant that happens. One introduces it and evaluates the effect on the plant to see whether it has the characteristics or effect that one wants. One then uses it in conventional plant breeding. I argue that that method gives precision. But when one makes a cross one often generates has good and bad plants. What is often forgotten is that with any breeding programme, be it plant or animal, one selects the best and makes sure that it breeds true and is stable in a range of environments. I suggest that modern technologies introduce an element of precision which does not exist in conventional plant breeding. But conventional plant breeding has been very successful. With this new technology we should be able to improve upon it and speed things up.

Chairman

299. If we are to take up some of the opportunities that you have described what needs to be done? What should bureaucrats and politicians be doing?

A. First, one should train the manpower who are motivated by research which underpins all this. We are facing something of a crisis in terms of recruitment certainly of United Kingdom nationals in these areas, not only because of student stipends but also because of the long-term job prospects. We need more money for research but you would expect me to say that. The other thing that we must do as scientists is to better inform the media, politicians and others about what we do and the basis of our science. I am involved in this more on the European scale. I do more of this abroad than I do here, although we are trying to put it in place in this country. We are trying to inform so that people understand. As someone said to me the other night, there is "red" and "green" biotechnology. If you are ill you will take any kind of poison. You will spray genes into your lungs and so on. But I argue that a lot more people in this world die of starvation and related diseases and the longer-term prospects are such that we need to educate people. I was phoned up by a journalist last week and asked to write a good news article of 1,000 words by Friday night. I did so. It was an article about the potential for producing vaccines in plants. Interestingly, the patent for

producing vaccines in plants is owned by a very small company in Cambridge, with which I am familiar. That company has a lot of the technology and, in combination with certain of the top scientists at the Boyce Thompson Institute in the States, is trying to create a business initially for the production of vaccines against diarrhoeal infections. It also hopes to produce a vaccine for hepatitis B and go to phase one clinical trials this year. You have heard about the encouragement of SMEs to allow entrepreneurs to take their ideas, evaluate them and to make the transition from a small organisation, which can very easily fail at the first hurdle, to a major pharmaceutical company. Pharmaceutical companies are not interested in orphan products with only relatively small markets. Normally, new innovations are competing against existing well-tried production methods which are very expensive.

300. But do you see the support regimes for different types of land use playing a part in this? Are they relevant, or should money not be spent on them?

A. My brother-in-law is a farmer in the West of England and I come from that sort of background. For many years I had the pleasure of serving on the priorities board of MAFF which was responsible for the arable crop sector. My understanding is that if there is a level playing field and our farmers, who are among the most efficient and responsible in the world, were allowed to compete without subsidies they would be quite happy to do that. Subsidies distort everything. I am afraid that I am not knowledgeable enough to comment on this. We are very short of land in this country. We import a lot of food. We import soya bean and corn that we cannot grow. I can provide one anecdote that may be open to question. I understand that when a farmer sows linseed even if it does not ripen and he just ploughs it in he gets the area payment anyway. Therefore, it makes money for him. To me, that is if not obscene then a nonsense. Linseed does not always come to fruition and the weather in this country is very variable, although if we wait around long enough global warming may be beneficial. The idea of having power stations burning rapid cycling miscanthus has some attractions. As part of my responsibilities I am a member of the Oxford Forestry Institute. One hears about carbon balance and so on. That makes quite a lot of sense to me. The use of plants to soak up carbon dioxide from the atmosphere and then recycle it is a good idea. We are a small offshore island where the weather is sometimes good or bad. On the whole, water is abundant but in the south east and elsewhere shortage of water can be a problem. We are supporting 60 million people in the United Kingdom where any other kind of rural economy would support only 3 or 4 million. There are opportunities but it is probably better to develop the technology and pay someone to grow it elsewhere where the sun is more abundant.

Lord Soulsby of Swaffham Prior

301. Can you put a timescale on developments in certain areas? You referred to vaccines. I am aware of some of the developments that have taken place in this field, for example the possibility of providing a rabies vaccine by putting it into spinach.

A. Obviously, I am referring to oral vaccines, and we can all see the advantages of those.

302. I am not referring simply to those.

A. I hate to admit that, although we understand a great deal and will soon have a complete gene sequence for a small plant (Arabidopsis) and probably also rice and maize, the fact that we know the sequence of all the genes does not tell us everything. We will not know what many of them do. Plants are very "clever" and can grow in almost any environment from the top of mountains to the bottom of the sea. They have an incredible ability to survive in a diverse range of environments. One aspect of that is that often they make compounds or enzymes that allow them to grow in those environments. By understanding those systems and the chemicals that they make which allow them to survive in those environments, whether they grow in high or low temperatures or high salinity, once we have isolated genes that we know confer a trait—it is unlikely to be one gene; it may be several—we can put them into elite crop variaties where there is a need for it. It must be competitive with the crop varieties that will be there in 10 years' time anyway. Even with this technology, having identified the gene and undergone proof of concept one is talking of at least 10 to 20 years to get even to the early stage with single monogenic traits before one sees any payback. Then it must be taken up by industry, which means that often it will replace existing technology. It must be taken up by someone who can afford to develop it. To do the science is relatively cheap but to bring this through into production is much more expensive. There are competitive reasons why some people will want this business to succeed and others will not. I imagine we will know whether oral vaccines will be effective within five years. If one considers biodegradable plastics from plants, that is now being done in oilseed rape. There is considerable progress being made in Canada, for example, where they grow something called canola which is their form of oilseed rape. My guess is that they will be producing that on a pilot scale fairly quickly. Another example is the modification of starch content. There are people who claim that they have succeeded in doing that. This is what the Zenecas and Duponts of this world are investing in. Zeneca does not put £50 million into John Innes Institute unless it sees something that on the economic and planning timescales that it uses will give a return. The people involved probably tell their main board that it will take five to 10 years. The main board will assume that it will take less than three. Reality is that it is probably nearer five to 10 years.

303. The problem faced by SMEs in this field is that they cannot keep going for 10 or 15 years.

A. They must go for refunding. These initial public offerings in the biotech sector where SMEs go public are not moving forward. There have been a lot of casualties. Their hope is that they will increase their overall value to the extent that someone will pay £50 to £100 million to buy them out. I was on the advisory board of a small company called Mogen in Holland since its beginnings. Among other things, it owns the patents on the technology for plant

Lord Soulsby of Swaffham Prior *contd.*]

transformation. It engineered the gene for an enzyme called phytase and introduced it into plants. This had a greatly beneficial effect, as it meant that the utilisation of phosphate by chickens and pigs was such that there was less environmental pollution and there was lower phosphate in feed. Initially, that enzyme was made by growing an Aspergillus fungal culture and compounding it into the animal feed. As soon as this invention plus one or two others looked promising Zeneca bought the company for £50 million. I think it is unlikely that we will see many more of these initial plant pharmaceutical SMEs unless it is a real niche market and adequate venture capital.

304. Do you see the need for the development of biotechnological incubators in this country comparable with what happens in, say, North America?

A. I believe that if the culture in universities is allowed to develop and the public does not fight against it, yes. There are a lot of entrepreneurial scientists. Most scientists do the job because they like doing it, enjoy teaching, asking scientific questions and are prepared to be responsible but there are also some who would like to make money as well. I am one of the directors of my university's technology transfer company ISIS Innovations and Chairman of the Universities Technology Transfer Advisory Group. We find that a number of scientists have both the scientific skills to identify something (an invention) that will make money and also the interest at a certain stage of their lives to try to take that through to the market place. We should encourage that. There are science parks around most major universities nowadays. The new Zeneca building at the John Innes Institute will, with little extra money, house an incubator where people can try to spin out ideas. But, as with patents, if one in 100 or one in 500 works and makes money that is considered to be a success. In this country we are good at failing cheaply but not very good at recognising successes and opportunities and then reinvesting in them.

Lord Marlesford

305. I should like to focus on land use. I see the total relevance of what you have been saying about fuels, high-yielding food crops and bio-plastics which are biodegradable. I turn to pharmaceuticals. First, am I right in thinking that in general the land area needed to grow these new products is relatively small? Secondly, what tends to happen is that a product is made and then attempts are made to synthesise it. One remembers people going round collecting yew cuttings because it was regarded as a wonderful new cancer drug. The sudden demand for yew cuttings went up and someone sought to synthesise it.

A. You are thinking of something like taxol which is extracted from yew. Because of the nature of the pharmaceutical product it will be relatively small scale. One should be able to produce these in plants. The added advantage is that if you can produce an oral vaccine in a plant then certainly in the States the regulatory hurdles of the FDA will be much lower. One will not face the sort of requirements that one has for normal pharmaceuticals if the efficacy of the product is proven. Oral vaccines would have distinct advantages and the formulation would be very simple. One would have to make sure that one had the dosage right and on a bulk basis one should be able to do that. Set aside is currently seven per cent. People will take the money for that and may grow something different, this may be a real advantage; otherwise, I think that we should allow people to utilise the country in the way that they wish. As to biodegradable plastics, I am not certain about scale. It may be that there are certain regions of the European Union where that may be more profitable. Most of these things would be niche markets where on the whole they would be high value products, except perhaps for bio-fuels. I am not talking about now or next year but future generations will have to find alternative sources for gas and petroleum-based feedstocks on which our society now runs. Our agriculture depends on those products. Various experiments are taking place, for example in South America. Brazil is making plant derived gasahol.

306. Can you deal with my question about the tendency to identify a certain product and then synthesise it?

A. I apologise, I went off at a tangent. Most of these products are produced by microorganisms in fermenters. In the case of pharmaceuticals we have been very aware of the problems associated with contamination of fermenter technology. You have heard about the problem of the amino acid tryptophan that is produced by genetic engineering with yeast. That was a failure in the process, not with the organism. The economics are that the sun is free and if you can make it in a plant it is cheaper. To produce a modern-day vaccine is very expensive. If you can produce that in a plant theoretically you can do it for one-hundredth of the cost. People are not interested in a 10 per cent saving; but a saving of that order of magnitude will generate considerable interest. We are at the early stages. It is rather like the time the wheel was invented. People tried to imagine what it could be used for. If there is public acceptance of the need it will be done. If you are desperate enough you will do it. If for whatever reason we were cut off from our supply of a product from one part of the world it is quite possible that we can engineer plants to make it for us in the United Kingdom.

Lord Rea

307. I am delighted that we have before us one of the leading plant scientists. I have been wanting to ask this question since last Friday when I read an article in the *Guardian* by an American, whose name I have forgotten, who suggested that global warming, far from being a disaster, will lead to a garden of Eden and is something to be welcomed. One of the things he said was that the increased level of carbon dioxide in the atmosphere would accelerate plant growth and crop yields. He cited a case where Dutch horticulturalists were increasing the carbon dioxide in the atmosphere in their greenhouses.

A. There are some distilleries in Scotland that do that because CO_2 is a by-product of fermentation. Certainly, increased amounts of carbon dioxide can

Lord Rea *contd.*]

enhance yields. There is no doubt that yields in some parts of the world will increase because of higher CO_2. The other environmental effect is that the prevailing agricultural and environmental conditions that you find between Paris and Lyons, say, may eventually be found in the southern part of England. Equally, the Sahara desert will probably advance beyond North Africa.

308. He adduced certain arguments to demonstrate that that would not happen.

A. Global warming is a reality. Plants are very good at adapting. There is a lot of sun and CO_2 around at the moment. We will be short of water. I am far more concerned about the sustainability of water supplies in many parts of the country and the world. As our population increases we use more water. Most of us in the south east of England at some time or another are subject to a hosepipe ban. When I go to Norwich I am amazed to see mass irrigation. Irrigation tends to leach out the salt and bring it to the surface, which brings with it problems of salinity. Global warming will not achieve everything. The climate here will be a bit better. Yields may go up marginally, but there are always downsides. It may well be that one has to select or breed plants that better utilise the CO_2 because the enzymes involved in CO_2 fixation have evolved. Carbon dioxide levels have changed over recorded time and the enzymes have evolved to utilise that most efficiently. However, our ability to engineering those enzymes to improve CO_2 fixation may be quite limited.

Lord Porter of Luddenham

309. I like the way that you enthusiastically speak about plants as factories that can produce almost anything.

A. That is why I am a botanist.

310. I want to ask about the things that plants can do and are not doing for us very well. I refer to global warming and CO_2 and the competition between fossil fuels and renewable fuels from plants. What do you see as our way forward in research and everything else? We have liquid petroleum fuels. Liquid fuels are probably the biggest business that we undertake and transport. They will not be replaced very easily by coal.

A. Not in our time.

311. What do you see as the alternatives—mainly alcohol through fermentation? That is not done by the plant but by us, which makes the product pretty expensive. We also have beautiful oils in the form of bio-diesels which do the job perfectly well; they can go straight into your Mercedes. Which way should we go? Rapeseed oil does not have a hope of competing with that, and yet the Government are determined to cut down carbon dioxide. How will they do it? Where are liquid fuels to come from if they are not bio-fuels? Is it worth putting effort into making better bio-fuels?

A. My current understanding is that research into bio-diesel was very much in vogue 15 to 20 years ago, and certainly the Brazilians had as a target that a certain percentage of each litre of petrol should be gasoil or bio-diesel. We then started to find more gas and oil that could be exploited. Some people say that there are still 50 years of easy oil and then 100 years of difficult oil left in the world. Human beings are very ingenious. If the need is there then it will be utilised. We must do a radical rethink. As I drive into Northumberland or into Germany I see a convoy of lorries, with an individual in each, transporting goods when we might well be able to transport by trains driven by electricity or other sources. We must rethink the whole lot. The consequences of burning these fuels is higher CO_2 . There are talks of a carbon tax that could be traded all round the world and crop plants to fix CO_2 so that the balance is maintained. These are macro-economic and environmental considerations on which it is difficult to comment. I am sure that oils can be obtained from plants that can be modified so that they can be used to drive some kind of engine. But what is the cost? Will it be for the masses as now or just for specific services?

312. But would one be modifying existing oils like rapeseed on an economic basis, because they are perfectly satisfactory?

A. For example, I do not know what oilseed rape smells like when it come out of the back of a diesel engine, but I guess is that it can probably be improved or the engine can be modified in terms of efficiency and energy output per litre. I do not know. Whether or not research is being done on that I do not know. Presumably, somebody somewhere has applied for a grant based on the suggestion that we should be trying to modify it.

Chairman: Professor Leaver, thank you very much. Your clear views have helped the Sub-Committee a great deal in illuminating the issues.

TUESDAY 25 MAY 1999

Present:

Birdwood, L.
Hogg, B. (Chairman)
Marlesford, L.
Middleton, L.
Nathan, L.
Porter of Luddenham, L.
Rea, L.
Soulsby of Swaffham Prior, L.
Williamson of Horton, L.

Examination of Witnesses

DR PETER CARRUTHERS, Centre for Agricultural Strategy, the University of Reading, DR JANE POWELL, Centre for Economic and Social Research on the Global Environment, DR KERR WALKER, Scottish Agricultural College, Aberdeen, called in and examined.

Chairman

313. Lady and gentlemen, thank you for coming to give evidence to this Committee. Dr Carruthers, you seem to find yourself in the hottest seat. I hope this was with warning. Might I ask you to start by, perhaps, introducing yourself and your colleagues, if you would be so kind, and then, if there is anything you would like to say initially, or Dr Powell or Dr Walker would like to say to us, that would be fine. Otherwise, we will fire straight into something that I hope will vaguely approach the list of questions that I know has been circulated to you.

(*Dr Carruthers*) Thank you, my Lord Chairman, my Lords. My name is Peter Carruthers, I am a Senior Research Fellow at the Centre for Agricultural Strategy at the University of Reading. Over the last 20 years or so I have conducted various research projects on non-food crops. With some others I carried out a study of industrial markets for United Kingdom produced oilseeds, which reported in 1995, and then, more recently, I led the MAFF-funded project to compare industrial products derived from rapeseed oil with comparable products from mineral oil using Life-Cycle Assessment and Cost-Benefit Analysis. My main collaborator was Dr Kerr Walker from the SAC Aberdeen. Dr Jane Powell is also an associate in that she helped me with that study. Perhaps I could ask that they introduce themselves in their own words.

(*Dr Powell*) My name is Jane Powell, and I work at CESRGE, which is the Centre for Economic and Social Research on the Global Environment, based at the University of East Anglia and University College, London. Most of my research is on Life-Cycle Assessment on waste management and energy systems, but I have also done some work on energy crops.

(*Dr Walker*) My Lord Chairman, my name is Kerr Walker, I am Head of the Agronomy Department at the Scottish Agricultural College. My special interests are oilseeds and industrial crops. My colleagues and I have been working with Peter over the last three years on the LCA CBA project. My own special interests also include genetically modified crops and energy crops.

314. Thank you. You seem eminently qualified to write this entire report. We are most grateful to you for coming. Dr Carruthers, might I just start by asking you to give us a few pointers, if you would, as to how Life-Cycle Analysis can be used to evaluate some of the issues that we are concerned with here, such as biodiversity and visual amenity in particular?

(*Dr Carruthers*) The first thing I need to say is that our specific study, recently completed, did not address these issues directly. I think I am right in saying that our research is probably the first piece of research in the United Kingdom that compared industrial products from crop feedstocks with mineral oils. The other point, of course, is that direct assessment of these two impacts and similar types of impact is the subject of much debate within the LCA community. There is the problem of definition and measurement of biodiversity and visual amenity. There is not a consensus on exactly how to achieve this. We understand what these things are, but in terms of measuring them we have difficulty in agreeing how they might be measured, or even defined. These things are complex and are determined by an array of factors, many of which are interacting. So, if you like, that is the caveat to my main response before I ask Jane to comment. There are three ways in which we did begin to approach the issues of biodiversity and, to some extent, visual amenity, but primarily the former. The first is that biodiversity is affected by emissions of chemicals, which were not only the main focus of our recent work, but are generally the business of LCA. Therefore, because we assessed chemical emissions within our LCA—and this would be inherent in all LCAs—we did assess the causes or determinants of biodiversity. The main categories of impact which we looked at, and which are common to pretty well any Life-Cycle Assessment—are acidification (acid rain), eutrophication and eco-toxicity. So the first way in which we moved towards biodiversity within the LCA is through the assessment of chemical emissions. Another dimension is the change in land use which will affect both biodiversity and visual amenity. One approach that is used (not within our study, but is used in some Life-Cycle Assessment) is to try and evaluate land transformation, and to measure it in terms of the number of years it would take to return a piece of land to its former state. Our study, in fact, did not do it that way. We did not do it within the Life-Cycle Assessment, but using the

Chairman *contd.*]

Centre for Agricultural Strategy's Land-Use Allocation Model. This model is a model to explore the impact of policy change on land use and farm financial performance. What we did was to look at the effect of markets for industrial rapeseed on land use, and some of the knock-on environmental impacts. Our conclusion was that the impact of expanding industrial rapeseed in the United Kingdom would be slight, and the reason is that production would take place on existing arable land or set aside using similar methods. So that is chemical emissions and land use changes. The third point is that we did do a very partial analysis of some of the road transport implications on the products we studied. This again is common to many Life-Cycle Assessments. That would provide us with some indication of visual amenity as well as other amenity related concerns, like traffic noise and traffic congestion. Those are three immediate responses, but maybe Jane could develop that for us.

(*Dr Powell*) First of all, I will take a step back. Traditionally Life-Cycle Assessment was used to determine environmental inputs (that is resources) and outputs (which are emissions). So it was never intended to include issues such as biodiversity and visual disamenity. LCA was initially developed within the factory gates and then slowly started to take into consideration mining resources, the use of the product and then the disposal of the product when it was finished with. However, many Life-Cycle practitioners now realise that impacts such as biodiversity and visual amenity are important, particularly in the decision-making process. One of the problems of including these areas is that Life-Cycle Assessments are often generic rather than site specific. So you can measure the biodiversity of a specific field—that is not a problem—but not if you are talking about a generic study. With biodiversity, however, you can talk in general terms. For example, the biodiversity of a short rotational coppice is almost bound to be very different from a wheat field. So in general terms biodiversity can be determined. Visual amenity is more difficult because it will vary with the local geography; how easily it can be seen. It will also vary with an individual's attitudes, both to the crop but, also, perhaps, to farming and the countryside in general. For example, if you look at oilseed rape some people think it is very attractive whereas others think, more traditionally, that it is undesirable. So the only way to put a value on something like visual amenity is to ask people either as part of an economic study or focus group.

315. These problems of measurement arise in traditional, economic analyses of externalities. I suppose what I am trying to get at is does Life- Cycle Analysis give us a tool over and above those traditional techniques and ways of looking at these problems, or not?

(*Dr Powell*) I think Life-Cycle Assessment can be combined with other tools, particularly with economic evaluation. I think that is where its strength lies.

Lord Birdwood: to some extent, Dr Carruthers, your opening two or three sentences shot my fox. However, from what you were saying there are a number of questions which immediately spring to mind. First of all, I was very interested in you saying "the LCA community". Could you describe what that affinity group is?

Chairman

316. I thought you would get that one.

(*Dr Carruthers*) I suppose, like any methodology that has developed in the last 20 to 30 years, which has a kind of history behind it, of origins and roots and so on, it is now developing protocols, procedures and agreed international standards. So when I talk about the LCA community I mean those people who are practising LCA or researching it as a methodology. That is an international community.

Lord Birdwood

317. Who benchmarks the protocols?

(*Dr Powell*) ISO (International Standards Ofice) - standards have been set down, which is why I talked about Life-Cycle Assessment and not Life-Cycle Analysis, because the iso-standard is Life-Cycle Assessment.

318. I did notice the difference. To what extent do the international community recognise these protocols?

(*Dr Powell*) They are European standards and in America they have similarly associated standards, so they are international.

319. How much take-up do you think is current in terms of what might be called your eventual customer community? That is companies, even banks, or financial institutions, hoping to invest. To what extent are they building the results of your modelling in to decision-making? From that, of course, flows, how robust is it itself to hostile analysis?

(*Dr Powell*) Life-Cycle Assessment has been used in waste management a great deal and several policy assessments are based on Life-Cycle Assessment. The Landfill Tax is based on a Life-Cycle Assessment that we carried out at CESRGE, so it is a recognised and well-used technique.

(*Dr Carruthers*) Perhaps I could come in from the agricultural point of view. Jane Powell works, in a sense, within a wider framework of Life-Cycle Assessment. We have developed Life-Cycle Assessment for agriculture, and that is a context where it is probably not true that there has been this uptake as yet, either by agri-business or by policy makers—and, to some extent, the work is pioneering.

320. Lastly, you gave, as one of your baseline criteria, the length of time to return a piece of land to its original state. That, of course, infers a moving target as your control, because its original state could be rich, East Anglian arable land or it could be a rocky landscape. Is each LCA that you accomplish heuristic or algorithmic?

(*Dr Carruthers*) Taking the issue of land use change, we recognise that has been used, but we did not actually assess it within our study. I do not actually think it is very useful for the crop production part of the system. It is something that has been used more in industrial systems, where there may be construction of an industrial plant or landfill site and an estimate of how long it might take to return that

Chairman *contd.*]

to its original state. Obviously the severity of the impact on land use depends on, if you like, the extent of the change, for which a proxy is that number of years. It is not a very well developed technique at the moment.

Chairman: Perhaps we should move on to agricultural applications.

Lord Soulsby of Swaffham Prior

321. To a certain extent part of my question, about sites generic, has been answered by Dr Powell, but coming back to the general issue in agriculture, to what extent are Life-Cycle Analysis specific to the crop from which the product is made and the location where the crop is grown? Perhaps you might expand a little on the question of the generic aspects of the site evaluation.

(*Dr Walker*) My Lord Chairman, if I may answer that. By definition, LCA is for a specific crop and for a specific end use, because one of the first stages in our LCA is called "definition scoping" and that involves deciding what the whole basis of your comparison, or your study, is going to be taken on. So, if I can give you an example, where we, in our study, were looking at lubricants we look at the lubricant that is used in chain saws—chain saw oil—which is a lubricant which is completely lost into the environment. The other lubricant that we looked at was the lubricant that is used in diggers—hydraulic fluid lubricant. If you take those two examples, the functional unit there differs completely when you are comparing it with mineral oil, and the reason is that when it comes to chain saw oil you only use 60 per cent of the oil if it is vegetable based compared with 100 per cent if it is mineral based. However, when it comes to hydraulic fluid, the same amount is used. So here we are looking at the one crop—oilseed rape—but your comparison is different even if you are looking at that one crop, if the end use is different. So, to answer the question, Life-Cycle Analysis will be specific to the crop and may be more so specific to the end use of what you are actually producing from that crop.

322. Before you go into the second part, can I ask this: with GMOs that are used these days, would you have to do a completely new Life-Cycle Analysis if you had a genetically modified crop, or could you just tweak that little bit of the analysis?

(*Dr Walker*) That is an extremely complicated question and touches a great number of very interesting issues. If it were proven that there were health damages coming from the GM rape then that would obviously have implications in terms of your valuations, because that would come into play in terms of the health valuations, which is one of the categories you can look at in terms of damage to the broader environment—human health and so on. If you have isolation requirements, that is going to have an impact on the neighbourhood, so there are issues there. If you decide that you are going to grow a GM crop for non-food use and the meal that is left after the oil has been extracted for this industrial use cannot enter its normal home—which is in animal feeds—then that would alter the whole calculation. So it could be a very complicated change, depending upon what the final outcome and what the final decisions are on the risks of the genetically modified organism to the environment. What I should say, going back to the very beginning, is that the first thing one ensures within a Life-Cycle Analysis is transparency. Right through all the decisions that you make in a Life-Cycle Assessment you have to explain what the different options—of how you have allocated damages to the environment, or whatever. You have to explain the different options and why you chose a particular one, so that in future other workers can come back and reassess whether what you have done is correct, because technology will move on and all sorts of different issues will move on as we learn more about whatever it is that is being produced.

323. You are getting on to the point I was about to ask. Is there a sort of factor of public concern that you can fit into your analysis here, like a constant, shall we say?

(*Dr Walker*) Can I pass that on to Peter?

(*Dr Carruthers*) I think one of the key aspects of Life-Cycle Assessment—in common with Cost-Benefit Analysis—is the issue of value judgments. That is particularly evident in the weighting and monetary valuation of impacts. What the procedure does is to add up all the emissions to the environment—chemicals to air, water and soil—and the use of resources they are taken from the environment and then aggregate these into various impact categories, of which I mentioned some earlier on: acidification, eutrophication, human health and eco-toxicity. Those could then be weighted, or actually valued in monetary terms. Those weightings and values would reflect the methodology by which they were arrived at, and, therefore, the sort of values to whoever is the stakeholder or constituency that is consulted in the development of those weightings. So public concern may, therefore, affect the weightings and, therefore, that would work through to the assessment.

Chairman

324. Dr Walker seemed to me to be making a very interesting distinction in that analysis of the methodology, or the inputs into the analysis, between, as it were, assessment of impact—particularly on health and environmental factors—and assessment of policy responses to those risks. So your example of stuff left on the ground that cannot go into animal feed is a factor that stems from policy, if you like, not just from the analysis of the risk. Presumably concern is getting fed through in the policy response.

(*Dr Walker*) Yes. Again, that is difficult to elaborate on.

325. If you take policy responses, I suppose at least they are a proxy for public concern—with a lag.

(*Dr Walker*) Certainly, as far as the research community is concerned, the concern relating to GMs—for example, the meal issue—is one that has stimulated considerable research over the last two years into non-food uses for meal. So we are anticipating difficulties, if you like.

Lord Marlesford

326. Can I follow up what the Chairman was saying. In a sense I have got slightly confused between analysis and assessment in respect of this particular tool which we are discussing this morning. Am I right in thinking that the assessment is all part of the process of analysis, or is the assessment a product of the analysis?

(*Dr Powell*) It used to be called Life-Cycle Analysis and it was a fairly narrowly defined methodology. It now has internationally accepted standards, and is now called Life-Cycle Assessment. So Life-Cycle Analysis is an old term, if you like.

327. I wanted to ask you about the extent to which this tool shows significant differences between non-food crops and food crops in terms of impact on the countryside. This has already, to some extent, been referred to when you talk about rape. I was thinking perhaps we could break down the impact on the countryside into three parts: first, the agricultural sustainability of land; secondly, the financial sustainability of agriculture and, thirdly, the amenity of the countryside in terms of both landscape and access and recreation. I wondered whether you would tell me, taking any examples you like—except I would like, obviously, oilseed rape to be one of them, because it is one of the most important, where there is a clear alternative use to a pretty similar crop—about those three categories.

(*Dr Walker*) My Lord Chairman, if I could answer, or attempt to answer, that one. As far as oilseed rape is concerned, if that crop is going for non-food crop use or food use then the inputs and outputs are going to be exactly the same. There will not be any difference to the inputs and outputs. So, as far as the field crop within that environment is concerned, the LCA will not be different, it will be the same. There will be no difference whatsoever, as far as that field is concerned. The only area where it may differ between non-food and food crops, in terms of their impact on the countryside, could be, for example, if one changed the growing system for your non-food crop, for example, by using it as an opportunity to get rid of sewage sludge. Then your LCA would change because the application of sewage sludge as opposed to the application of conventional, mineral fertilisers, would have all sorts of implications as far as nutrient run-off, smells and movement of various compounds into the atmosphere, etc, etc, is concerned. So, basically, the answer to that is whether the crop goes for food use or non-food use, as far as the countryside is concerned that would not have any impact.

328. If you remember, my second category was the financial sustainability of agriculture. As I understand it, farmers now have the alternative of a 10 per cent minimum set aside, which means, basically, growing nothing, or growing a non-food crop. So, to that extent I would not have thought there was a distinction between growing oilseed rape on set aside land and oilseed rape for non-food use. The essence of the question, I suppose, is in what circumstances would farmers choose not to have set aside because it is more profitable not to have set aside on which nothing is grown, but to have set aside on which a non-food crop is grown, because it is more profitable? Taking rape as an example.

(*Dr Walker*) That then is a different question completely and I heartily agree with what you are saying.

329. I thought it was the question I asked.

(*Dr Walker*) With the LCA work that we did, what we looked at was oilseed rape growing, but we looked at oilseed rape growing in a number of different scenarios. Where we looked at oilseed rape being grown to produce whatever, then the question comes back to what would that land have been used for if it had not been used for oilseed rape? In one's comparison, then, any effects to the environment that the field of oilseed rape has should have, we believe (with the alternative of set aside), the impacts that set aside would have deducted from it. If you are with me.

330. If I can just stop you there for a moment, the object of set aside, as far as I am aware, has nothing to do with the environment at all; the object is entirely in order to reduce the product of various field crops.

(*Dr Walker*) That is correct.

331. So what I am getting at is what is the impact of non-food crops as an alternative, or, if you like, a supplement to set aside? Is this going to have a big impact?

(*Dr Walker*) Just to take that a little bit further, if you grow nothing on a field then there are certain environmental negative effects that take place. The principal one, for example, is nitrous oxide leaving the field. That is one example, and there are lots of other things. Where one grows oilseed rape, then some of those negative aspects that would be there from set aside are happening anyway. So one deducts those from the effects on the environment that are coming off the decision to grow the rape. The decision to grow the rape, as far as the farmer is concerned, is, really, simply, a financial one within his system. He is not aware, I very much doubt, if he is taking into account the sort of broader, LCA aspects. In my experience, the decision of the farmers I know tends not to be environmentally dominated as far as whether to plough up a field that is in set aside and put it into industrial oilseed rape is concerned. I think it is important to separate from one's mind any financial aspects in the decision-making process that the farmer has compared with the LCA environmental issues that are there in terms of that decision to grow the crop. In many ways the whole purpose of LCAs to indicate the benefits or disbenefits to the community at large from growing industrial crops, which may allow policy makers to see that there is an advantage there in growing the crop or not growing the crop, which can then be encouraged through some sort of grant, or whatever.

332. So you are basically saying that there is no environmental advantage or disadvantage in, for example, growing oilseed rape on a field versus it being in pure set aside?

(*Dr Walker*) No.

(*Dr Carruthers*) The impacts in the field on the countryside are probably more or less the same, whether the crop is food or non-food. The strength of Life-Cycle Assessment is in examining the whole product life cycle. So, in fact, growing non-food crops might be delivering some benefits, both in terms of reducing the use of scarce fossil resources,

Lord Marlesford *contd.*]

and in reducing some downstream impacts that may be more severe if the product that it replaces is derived from mineral oil and is producing a high level of, for example, particulate emissions. That is where the Life-Cycle Assessment approach has the strength—to look at the whole cycle. Using Life-Cycle Assessment to compare food and non-food crops is more problematic because they deliver a different utility and so we would have to look at it in terms of land use. We regard that as the functional unit, using land, and therefore there are all sorts of other ways we could use land. So, in that sense, I think Life-Cycle Assessment, given some development, could answer the question "What is the relative environmental impact of food and non-food crops", but I am not aware that it has done yet and not in any other studies. If I could, perhaps, go back to your earlier question—what are the financial impacts—what we did do within our recent study was to ask that question using a different methodology, which I mentioned earlier, the Land Use Allocation Model. What we did conclude from that was that if there were markets for industrial rapeseed oil in the various sectors we have identified (and we looked at several levels at which they might exist) then this would have a fairly minimal effect on land use relating to the environment, but would improve average farm gross margins and would create some employment. In that sense, to the extent that one would have to look at the assumptions behind the model and so on, nevertheless we seem to be identifying some benefits from markets for industrial use.

333. Did you find that the vulnerability was still dependent upon the farmer still getting the set aside premium? In other words, supposing the powers that be in Brussels said "The object of set aside payments is merely slightly to compensate for not growing a food crop, but that if they are going to do something else with their land we have no obligation to compensate them in that way", would this have a big impact—taking rape in particular or any other crop you like—on the production of non-food crops?

(*Dr Walker*) As far as the farmer who decides to grow a crop on set aside is concerned, because the area payment is the same whether he does something or not with that land, the decision really depends upon the profitability of the enterprise. The common factor is the set aside payment, whether the set aside payment goes up or down has no real bearing on his decision whether to grow something on that land or whether not to grow something on that land.

334. It would, in the sense that, if the choice was grow nothing and getting the set aside payment or growing non-food—oilseed rape—and no set aside payment. That is what I am asking.

(*Dr Walker*) Our model assumed the area payments.

335. But if it were to disappear? This is something we must consider. Farmers are given an agricultural subsidy for non-food.

(*Dr Powell*) If there was no payment for set aside the farmer would then be saying "Shall I grow wheat or shall I grow oilseed rape?" So it would depend on the profitability of those two crops.

336. I am sorry, the point I am making is that you have got the set aside regime, and assume it is given, but the set aside regime includes compensation payments for land which is set aside, but now we have this relatively recent development of using set aside for non-food crops and still getting the set aside payments. So those are additional. What I am trying to get at is whether it is really significant in economics or whether you believe that the market, if you like, for oilseed rape, of a non-agricultural, non-food nature, is sufficiently robust that even if they were to scrap the payments for set aside it would still flourish.

(*Dr Carruthers*) It is a very complex question, and going back to our model runs, these indicated that a lot of the land that took up industrial rapeseed was land that was not in set aside, it was land under the main scheme, but that includes the area payment. We did not run it with free market or world prices—not for this. It would be interesting to do that, but the problem, of course, is that if we had no area payments at all relating to production—which may be where we are going—then we would have to look at the effect of global markets, and that is why I do not think I can answer the question.

Lord Williamson of Horton

337. I just wanted to make one point. Surely you cannot draw a general conclusion about the comparability of the effects of growing an ordinary agricultural crop or growing a non-food crop. I can see, in the case of oilseed rape, you can draw certain conclusions, but if we look at other non-food crops the differentiation would, perhaps, be much greater, for example, if you have a field of grass covered in sheep and you decide to shove the sheep off and plant a short coppice rotation willow. You are making a very considerable difference, actually, in the environmental effect, in my opinion; for example, the use of nitrates, etc, that is taken up through water in the soil and a lot of other changes of that kind. I think it is a bit difficult to draw a general conclusion. Perhaps I got the impression that you draw a general conclusion that the use of non-food crops in place of another crop does not make a very big difference to the environment, but in some cases that certainly will be the case. Would you like to comment on that?

(*Dr Powell*) It would vary considerably between the crops, as you point out, and also the region we are talking about. So in one part of the country it might affect biodiversity differently.

338. We are told that as far as Life-Cycle Assessments are concerned they do not address economic considerations, but in reality it is a bit of problem, I think, for this Committee. Since, with effect from yesterday, we have freedom of information everywhere, I may, perhaps, say that I think that when we come to our report we will have a bit of difficulty over some of the Cost-Benefit Analyses. If you look at the non-food crops, the assessment of the costs and benefits depends so much on these variables, which Lord Marlesford has referred to quite a lot; that is to say, what sort of grant system there is going to be, and how far it is likely to be viable over a period of time. As we know the Commission proposed to abolish totally the

Lord Williamson of Horton *contd.*]

default rate on compulsory set aside—they wanted it at zero. (They did not get it but they will come back to it.) So there are a lot of changes in the economics and the financing and so on of these crops. I wanted to ask you whether you could comment on how these two things go together. I know you would probably like to keep them apart but it seems to me that these variables, which we can all see and which affect the crops' financial viability, are going to affect the calculation of the Life-Cycle Assessment.

(*Dr Carruthers*) Can I ask Jane Powell to bat on that one first?

(*Dr Powell*) As you are aware, Life-Cycle Assessment is used to measure resource use and environmental emissions throughout the Life-Cycle. Cost-Benefit Analysis, on the other hand, looks at the costs and the benefits of a particular product or system. However, a full social Cost Benefit Analysis will not just include the financial costs, it will also include what we call externalities, such as the environmental damage. So when we talk about emissions it is the damage those emissions do to the environment that is of concern. So the results of Life-Cycle Assessments can be used to inform a social Cost-Benefit Analysis. It can help broaden out a Cost-Benefit Analysis so that it is not so narrowly focused and an economic or monetary value can be placed on the emissions. If, for example, an economic value is put on carbon dioxide emissions, we can do what the economists call internalising the externalities; they put a financial cost on these emissions. Then this external cost can be added to the financial cost. This is an area of research we do in CESRGE. When we do a Life-Cycle Assessment the results are a range of emissions.These can be grouped together into problem areas, such as global warming potentials and ozone depleting potentials. However, if we are trying to make a decision we may find, for example, that generating electricity from short rotational coppice might be better in some problem areas such as global warming but worse in another problem area, when comparing it with electricity made from coal. So we need to weight these different problem areas. That is where in CESRGE we use economic evaluation to make that weighting, and that is what we did to get an economic value for the Landfill Tax.

(*Dr Carruthers*) One of the interesting aspects of that question is that Cost-Benefit Analysis and Life-Cycle Assessment have quite a lot in common; they both reflect societal values, and they aim to indicate the value of an object of study to a defined constituency. I think, in that sense, they are similar, in that they are trying to work out the cost of things aside from the market—determined by the market—and, hence, to aid decision making. They also try to value things that we might regard as invaluable. What we did in our work was, primarily, to bring Cost-Benefit Analysis and Life-Cycle Assessment together via the economic valuation of environmental impacts. Those valuations are derived by the methods used in valuing externalities in Cost-Benefit Analysis. We also (again, going back to the land use model) looked at the impacts of industrial rapeseed production on farm gross margins. So we extended that beyond the strictly environmental questions that a Life-Cycle Assessment deals with.

Lord Rea

339. My question, I think, takes the discussion we have been having a little further, on how LCA—whatever we call it, assessment or analysis—can be used to develop policy, presumably, for future use. I wonder if you could look, in some rather overall way, at considering LCA and how it could be used to look at the effects of non-food crops on the countryside or the case for renewable energy, or the development of environmentally friendly lubricants. I think we have touched on all these things in our discussions so far, but I wonder if you could home in a bit more.

(*Dr Walker*) My Lord Chairman, if I can commence on that one. What Life-Cycle Assessment can do, where one is comparing for example a material from mineral oil with a material from a renewable source (from agriculture) is decide whether the cheap price of oil is really a true reflection of its costs in society. That is basically what we have been trying to do. I think what we can do with LCA, where we compare mineral oil with vegetable oil, is indicate how robust the comparison is using sensitivity analysis; try and indicate whether there is a true difference between the two in terms of their impacts on the environment, and that information can then be used by policy makers in different ways. It can be used bluntly, for example, by reducing the tax if it is an environmentally friendly product. For example, if chain saw oil is environmentally friendly, if it comes from a vegetable source, then perhaps there is an opportunity to remove the tax from the lubricant to reflect the fact that it is less damaging to the environment. Another option would be, for example, what is done in Austria, whereby it is a legal obligation to use a vegetable oil in forests where you are using a chain saw so that it has to be from an organic source. The other alternative is, if you like, non-interference by the development of, for example, eco labels. This has been done in Germany where you have a Blue Angel eco label where a product is entitled to have a stamp or mark on it indicating that it is an environmentally friendly product. So there are a number of different ways in which the conclusions of Life-Cycle Analysis can be used. Those I am just touching on very superficially (and I will pass over to Peter) but those are broadly the sort of things that could be done with it.

(*Dr Carruthers*) To broaden it out a bit, can I make four points on using Life-Cycle Assessment in developing policy? The first place that it might be useful is in choosing options, deciding whether to—in our case and in this Enquiry's concern—develop non-food crops as against continuing to derive the same sort of products from mineral oil. I think our work has shown that LCA can help to make that choice. Whereas we got, I suppose, quite a lot of variation in the results—for instance, on the monetary valuation of some of the environmental impacts, depending on the sort of methodologies and sources of data and so on—what was pretty much consistent through the products we examined was the hierarchy; that, in general, we were getting a kind of positive environmental benefit from the rapeseed oil-based products. So I think the Life-Cycle Assessment can help us to choose options. The second question

Lord Rea *contd.*]

you might ask, and which we were asked from the beginning of this work, is can it be used to set levels of support payments, because Life-Cycle Assessment is adding up the environmental impacts and the environmental externalities and, therefore, looking at the costs and benefits to society. Can monetary valuations within the assessment be used to set levels of support? I would say the answer to that is, theoretically, yes; but, in practice, I would be very cautious, at this stage, of using the results of this kind of work, at the present level of development, to actually set the levels of support payments. I think monetary valuation allows us to aggregate externalities to arrive at meaningful results, but I am much less sure that we are in a position to set levels of support.

340. I think all three of you emphasise that this is a method which has been developed to look at a specific crop, for instance, rather than looking at the generalised impact of several changes happening at once. Have you actually looked at widening the scope and looking at methods in a more multifactorial way, which might be possible? There are, as I am sure you are familiar with, statistical methods of using electronically stored databases so that you can actually change the variables concerned, and you can perhaps, therefore, predict several different outcomes.

(*Dr Walker*) Any Life-Cycle Assessment can be varied, in terms of assumptions about the product system, the way the product is produced and, also, all the contributory burdens, valuations and the weightings of those valuations, and the impacts that they have. That is possible. I would be less sure as to whether it can be used to explore a policy. It may be, but we have not done it. Its development in the last few decades has been as a means of assessing the environmental impacts of the production systems, but the product needs to be defined and described in terms of functional unit. I am not sure that the method would enable us to look at the environmental impact of policy making.

(*Dr Powell*) I think it probably could be. It has been in waste management. Non-food crops or agricultural systems are more complicated, so I think the methodology would need development to do that. So I think it is possible but it could not be done at the moment. With a bit more work it could be done.

Lord Birdwood

341. Following from what Lord Rea has asked, have you ever done two identical LCAs—the same place and the same product but with completely different teams—and saw whether there was a difference in the outcome?

(*Dr Powell*) I have looked at different LCAs, not on agricultural crops but on newsprint, to find out why the LCA results came out differently. You can track them down to the assumptions that are made very clearly, and for paper making, which is energy intensive, the results vary almost entirely due to what energy mix you assume is going to be used. So that depends on what country you do it in.

342. Were those assumptions the product of judgments by individuals or judgments by—I do not know—a political community? I mean simply having two teams, possibly even to compete, to get some kind of control.

(*Dr Carruthers*) One of the first things you have to decide when an LCA is done is the boundaries you are going to have round your product system and the assumptions you are going to make. If you are in a different country or a different part of the country you will make different assumptions and that will affect the results.

343. So the answer to my question is actually no, you have not gone through that experiment?

(*Dr Carruthers*) I have not done it for agriculture.

(*Dr Walker*) Chairman, if I may give an example of the sort of impact that the assumptions can make. There are many ways they can overwhelm all the other aspects of the study and this comes back again to the need for transparency in the study. If one is comparing oil from oilseed rape with oil from mineral oil, what proportion of the environmental burdens associated with the oilseed rape oil do you attribute to the oilseed rape? Do you attribute 100 per cent because you are growing the crop for the oil for this industrial purpose or do you attribute 40 per cent because the seed contains 40 per cent oil? You allocate 40 per cent to the oil and 60 per cent to the meal. Or, as we have done, do you use a multiple effect, which is you take into consideration both the mass and the value? In our assumption we used 70 per cent allocation to the oil and 30 per cent to the meal. You can see how you can have a huge range of allocation decisions to make. It can have a huge impact on the outcome of your study. I hope that gives an indication.

344. If you put two different teams of human beings together and to see how their results varied, would you be able to judge from that to what extent individual subjectivity entered into the final assessment?

(*Dr Carruthers*) None of us has done that experiment in the way you described it. We may have moved towards it in that, for instance, Kerr's team and my own people looked at some bits in common and we came up with slightly different answers, but those reasons were to do with assumptions, to do with data sources and so on. In other words, if we used the same assumptions and the same sources of data we ought to come up with the same results. Where subjectivity comes in is perhaps not so much the researcher's subjectivity, but, for instance, where weightings or values are derived from studies that may be in very different contexts. Quite a lot of the economic valuation data that we use and Jane Powell's group might be using as well may have been derived from studies in the United States. We might find it very different if we were predominantly using European data to assess the same impacts. That element of subjectivity comes in, but I am not sure that we have any experience of researcher subjectivity. Theoretically, it should not be so because there is a defined approach, and the word transparency is constantly being used to describe Life-Cycle Analysis and the way it should be presented.

Lord Porter of Luddenham

345. We have not talked about the benefits of the products from non-food crops compared with mineral oil. You have mentioned mineral oil several times. Looking at it from the point of view of a Life-Cycle Analysis, what are the relative benefits of the oils themselves from non-food crops compared with mineral oils?

(*Dr Walker*) As far as the benefits are concerned, we looked at a number of different environmental aspects and in all the scenarios that we looked at the vegetable oil was better than the mineral oil as far as global warming potential was concerned. We conducted a number of different sensitivity analyses there and that re-assured us that was correct.

346. What is this comparison based on, on carbon dioxide?

(*Dr Walker*) Yes.

347. If you are burning that then you are burning the carbon and the hydrogen, of course. What is the difference between a mineral oil from that point of view and a vegetable oil?

(*Dr Walker*) As far as the crop cycling part is concerned, the CO_2 that is released from the oil is photosynthesised in the follow-on crops, so one can argue that there is a closed loop to the system there.

348. I was talking about the products rather than the whole process.

(*Dr Walker*) What you are specifically asking is does vegetable oil have any technical advantages over mineral oils?

349. Yes. For example, biodegradability is an important one and you mentioned it as a fuel for boats.

(*Dr Walker*) Where one uses oilseed rape based chain saw lubricating oil then the consumption is 60 per cent that of mineral oil, so that is one technical advantage. Generally speaking the advantages of vegetable oil as opposed to a mineral oil are not all that good. There are usually technical aspects where users or companies would prefer the original mineral oil.

350. What is the advantage of vegetable oil over mineral oil for chain saws?

(*Dr Walker*) Our study examined the lubricant for chain saws whereby the lubricant goes onto the chain to lubricate the chain as it moves quickly in the saw. Where that lubricant is vegetable oil based the consumption of oil is far less, it runs at about 60 per cent that of mineral oil because it has better clinging properties, it has better lubricant properties and it also has better temperature working properties.

351. This is presumably a general advantage, it is not just with chain saws, is it? If it is a good lubricant in one respect would it not be in most others?

(*Dr Walker*) I wish it were true, but the lubricant manufacturers have a multitude of specifications for just about every different lubricating operation that there is. Invariably there are additives that go in to make up a cocktail. The oil that we use, for example, in our cars is really a cocktail containing principally mineral oil, but other things are added as well. Generally speaking in high temperature, high pressure situations the vegetable oil is not so good, but there are opportunities for improving it.

352. And each would have their niche.

(*Dr Walker*) Each would have their niche and each has to be examined separately. As far as biodiesel is concerned, that is another huge area, but generally speaking the environmental benefits from biodiesel relate to things like degradability, low oral toxicity, i.e. you can take a mouthful of it and it is quite harmless. You can carry it on aeroplanes because it has low explosive capabilities. As far as emissions are concerned, the emissions from biodiesel are lower, apart from NO_x where they are about three or four per cent higher.

353. I suppose you can even fry your fish and chips in it, can you not?

(*Dr Walker*) You can indeed.

Lord Marlesford

354. We have heard an awful lot about chain saws and like Lord Porter, I had thought that it was merely an example of the advantage, but now I hear that it appears to be largely restricted to chain saws. Presumably chain saws are an infinitesimally small niche and therefore the significance in global environmental terms really should be ignored. Am I right?

(*Dr Carruthers*) There is truth in the view that chain saw-bar oil is a rather small market. The reason why we examined it and why it has been of great interest is that it is the frontrunner both in terms of the development of the product, it is available, you can buy vegetable oil chain bar oil, and because of the obvious environmental impact of spraying oil around in a forest, for example. We also looked at hydraulic oils which are not lost to the environment, but have a high risk of loss.

355. Surely the amount of oil which is sprayed around in a forest when you are cutting trees is not very significant just in terms of the environmental impact on a forest or on woodland. I had never heard of it.

(*Dr Walker*) Again, a lot depends on the situation. For example, the figure that is quoted is that one litre of mineral oil can pollute one million litres of drinking water. It depends on the catchment system, where you are, but theoretically one can see in the literature that degree of potential pollution. I am not saying that every litre does pollute it, but theoretically that is the potential and that is one of the reasons, for example, why the Austrians are so keen on ensuring that no mineral oils are used in chain saws in the Alps because that is obviously a major water catchment area for such a large part of Europe.

Chairman

356. How much oil do you use in a chain saw in an hour?

(*Dr Walker*) I do not know.

357. Are we talking about a litre or what?

(*Dr Walker*) My colleague will look it up while I answer a slightly different question. You are quite correct in saying that the chain saw is not going to be a huge user of vegetable oil. One can also say the hydraulic market is considerably bigger, but there is no way that oilseed rape oil could cope with a large

market. Just the sheer logistics of how much oil we get per hectare indicates that we have very small potential production in terms of oil. At the present time in the United Kingdom we have approximately 450,000 hectares of rape being grown for human consumption. One then has to think how much larger that area could be in the United Kingdom, how much oil that produces, what sort of market that could satisfy. There is absolutely no way it could satisfy the lubrication requirements, say, for our cars or whatever because that is a vast market. The market for lubricants is huge.

358. The point of my question was to get some idea both of the scale of the market and the scale of the potential pollution from this. You say it is one litre equals X of drinking water, but we need to know how much you use in an hour.

(*Dr Carruthers*) I am afraid we cannot tell you how much is used in an hour. What we do know is that to cut 1,000 cubic metres of wood takes 34 litres of vegetable oil chain bar oil, and 56 litres of mineral oil and that is also reflecting the fact that the vegetable oil is a more efficient lubricant. I suppose it depends on how fast you cut that thousand!

Chairman: That gives us some feeling of scale.

Lord Soulsby of Swaffham Prior: Is there an application here for other machinery that depends on the chains for driving power? I know chain saws go at quite high speeds, but there are other implements that rely on chains for driving power.

Lord Birdwood

359. And traffic vehicles.

(*Dr Walker*) You are absolutely right in terms of chains. One other niche market would be in the food industry where having machinery which is lubricated by vegetable oil is perhaps not going to be so unpleasant if there is some sort of pollution on to food as, say, for mineral oil. There are different opportunities there, but we have not looked at those because obviously that may be a commercial-type opportunity for those that are producing the oils themselves.

Lord Porter of Luddenham: I am rather surprised at the rise and not the fall yet of the chain saw in this debate. I have heard it mentioned many times that a potential use of vegetable oils is at sea and on the water. As you were saying some time ago, you need only a little bit of oil to pollute the water. I cannot remember what the amount was.

Lord Birdwood: It is one litre to a million of drinking water.

Lord Porter of Luddenham

360. I would have thought that you would have gone much more for the uses in marine engines and that sort of thing which use much more oil and they need less to pollute rather than the chain saw. You have not sold the chain saw very well!

(*Dr Carruthers*) We carried out sample case studies and in the case of lubricants we looked at chain saw bar oil and we looked at hydraulic fluid. We also looked at surfactants and plastics, although we have focused mostly in the discussion hereto on lubricant uses. The fact that we chose two lubricants is not really an indication that we considered these to be the only possible products, but these are the two products that we took through in the assessment.

361. Are there any other aspects that Life-Cycle Analysis leads you to which indicate particular benefits of the non-food crop oils over the mineral oils?

(*Dr Carruthers*) If I can lead us away from the lubricants to one or two of the other products. We looked at an example surfactant which would be used in cleaning products and personal care, and what we actually did was to look at the impact on manufacturing of the chemical comparing mineral oils with vegetable oils. We showed distinct advantages in terms of the impacts related to air emissions, not just global warming, but to smog, to human health impacts derived from air pollutants, from the distinct environmental advantage. We had some problems with the water and soil, mostly because agricultural production was resulting in nitrate run-off and pesticide pollution. That says nothing about the use and disposal of the product. This is simply in manufacture and the advantages were fairly clearly in favour of the vegetable oil products. Interestingly, for that part we compared oilseed rape oil, not only with mineral oil, but with palm kernel and coconut oil from tropical sources. The perennial tropical crops slightly outperformed, which is an indication, at least in part, of their higher yields per unit area and, also, that perennial crops in general are likely to result in slightly less pollution than annual crops.

Lord Williamson of Horton

362. Can I ask about the industrial rape seed oil that is being grown at the moment and the high erucic oils. What is the market for those at the moment? How much goes into surfactants, how much goes into slip technology for plastics, which is also quite a big market, and how much goes into lubricants? When we are looking ahead we need to have some idea of the orders of magnitude which I have not got quite got in my head at the moment.

(*Dr Walker*) My understanding is that currently there is around about 20,000 hectares of high erucic rape being grown in the United Kingdom at the moment. The bulk of that is going to Croda at Hull for the production of erucamide, which is the slip agent for plastics. My understanding is that that takes up the bulk of the market. That market in slip agents is growing at the rate of six per cent per annum and is expected to carry on growing at the rate of six per cent per annum because there is no likelihood of another product coming along to replace it principally because the plastic is frequently touching food and the American Food Agency has given it clearance and that is a major factor. So any competing product will have great difficulty getting over that hurdle. All the suggestions are that this six per cent per annum increase is likely to continue and my understanding is that the plant at Hull is the largest producer of erucamide in the world. That is a very sound good market and obviously they are very dependent upon that product having got their fingers

Lord Williamson of Horton *contd.*]

burned however many years ago it was when they used to source it from Eastern Europe.

Chairman

363. Could I just try to sum up the very interesting evidence you have given to us this morning. We have discussed a good deal of the methodology and I think we have understood a lot more about that. If you were to help us identify areas where developments in science and technology were or were not likely to make non-food crops more viable, more attractive, more extensive in terms of land use within certain fairly obvious assumptions we can make about changes in agricultural policy in the medium term, which crops would you point us to where you could say that Life-Cycle Assessment has added an extra star on these results and, therefore, in terms of environmental policy is likely to give them an extra plus rather than a minus?

(*Dr Carruthers*) I think the problem with answering that question is that we have not carried out Life-Cycle Assessments on any non-food crops other than those derived from rapeseed oil.

(*Dr Powell*) I have! The main LCA I have done is on energy crops. When we look at short rotational crops to generate electricity, there are very clear advantages over fossil fuels. Against it there is a financial cost, but when we considered the environmental impacts, particularly the reduction of greenhouse gas emissions, then energy crops are a clear advantage.

364. Do either of you wish to add anything?

(*Dr Walker*) I do not think so.

(*Dr Carruthers*) Perhaps as I have become so focused on the non-fuel industries in the last few years I have lost sight of the bioenergy uses. There have been studies in Life-Cycle Assessments in other European countries, as well as the work Jane has been involved in, of biodiesel and bioethanol and so on, but within the non-food, non-fuel uses then I think I am now on safe ground in saying that the rapeseed oil-based products are the only ones that have been subject to Life-Cycle Assessments and the indications are that the rapeseed oil products deliver environmental advantages.

Chairman: Thank you very much indeed. Thank you for spending so long with us this morning.

TUESDAY 15 JUNE 1999

Present:

Birdwood, L.
Hogg, B.
(Chairman)
Marlesford, L.
Middleton, L.
Nathan, L.
Porter of Luddenham, L.
Rea, L.
Selborne, E.
Soulsby of Swaffham Prior, L.
Walton of Detchant, L.
Williamson of Horton, L.
Winston, L.

MR MARTIN LIVERMORE, External Affairs Manager and MS MAIRI BLACK, Cereals Innovation Centre, DuPont [United Kingdom] Limited, called in and examined.

Chairman

365. Welcome to the Committee, Mr Livermore. I believe that you have had an indication of the questions on which we want to focus, although we only loosely follow the schedules. Is there anything that you would like to say by way of introduction? Perhaps you would introduce yourself and your colleague.

(*Mr Livermore*) My name is Martin Livermore. I am the external affairs manager of Du Pont [United Kingdom] Limited at the Cereals Innovation Centre in Cambridge. I shall leave with you a document that gives a little more background about the centre, so I shall not say more than that we have been part of DuPont only since the beginning of last year and we are relatively new to the non-foods area, but nevertheless, we see great potential in it.

(*Ms Black*) I am Mairi Black, working at CIC in Cambridge with Mr Livermore in the Biosciences Department.

366. Perhaps you would start by telling us about Dupont's specific interests in non-food crops and where you see the greatest commercial prospects?

(*Mr Livermore*) We see two main potential areas. The first one which I think is the more conventional one is the use of crops to provide feed stocks for chemical processes to replace feed stocks from fossil fuels. That is potentially a very high volume and overall high value use, but it depends on the economics of extracting raw materials from crops relative to the economics of extracting oil from the ground. At the moment oil is extremely cheap to produce. The second area, which I think potentially has greater value, is to use crops as a source of materials which do not exist anywhere else, which can be used to provide completely novel materials which may replace existing materials because of their utility. There are various positions between those, where you can for example produce improved monomers for the production of existing materials as well. Essentially, we see that as the position.

367. Would you like to identify which particular products you see as having viability in the near to medium term?

(*Mr Livermore*) Along with other companies, Dupont has been interested, for example, in the use of plants to produce monomers for the production of polyester. That is a good example, and one which is shared by others, of the use of a crop to replace an existing fossil fuel feed stock. If we talk about novel materials—materials for which there are no direct equivalents at the moment—in Cambridge we are doing work on the fractionation of conventional crops such as wheat, maize and similar cereals to produce fractions which in themselves can replace other materials, but have properties which are different from those materials. By that I would include film-forming non-starch polysaccharides and a number of other things that we can explore later.

368. How far away are those from an actual market?

(*Mr Livermore*) What keeps a lot of things from a market is not so much the technology, but the economics. In most cases producing significant quantities of a particular raw material from a crop leaves you rather a large waste stream. The philosophy that we have undertaken is to try to utilise as much of the crop as possible, not by the conventional route of using it as a fermentation source, but fractionating it to produce a series of high value ingredients. At the moment there is nothing that is technically ready for market, even if the economics were right. However, if the economics became easier, there are things that could be brought to market, I would say, well within five years.

369. Before leaving the technological side, is reliability of supply a problem?

(*Mr Livermore*) Because we are a little way from market, we probably have not gone into that question too deeply. In general, no, because most of our work in this country is concerned with conventional crops, grown in high volumes.

370. Would you like to add anything, Ms Black?
(*Ms Black*) No.

Lord Williamson of Horton

371. For some non-food crops, support programmes are important. Does that affect your business at all? I am talking about agricultural or research support.

(*Mr Livermore*) No, I do not believe that it does to any significant degree. We are not talking about novel crops, crops that are not grown to any significant degree. We are talking about commodity wheats, barley, maize and crops of that type. To some extent, the same material can be used for food

Lord Williamson of Horton *contd.*]

and non-food uses. We do not see the situation for non-foods as being different from that for food.

Lord Marlesford

372. To follow up an earlier point made in answer to a question from the Chairman, you referred to the price of oil as being a crucial factor. That is in respect of the feed stocks, and the chemical processes related to that. It does not relate to the second category?
(*Mr Livermore*) It does not relate to the second category.

373. On that first category, can you give us some ball-park figures for where it becomes economic?
(*Mr Livermore*) I am afraid that I cannot. I think you probably have had evidence from other people that would be more meaningful in that area. I could say that we do not see a great future in the medium term for a direct replacement for—to use the same example—commodity polyester. However, we see a big potential for improved varieties of essentially the same polymer. There the economics become a little hazier because you have something that intrinsically has a higher value than the current product. I am sorry that that is not a very clear answer.

374. Is the second category also sensitive to the price of oil?
(*Mr Livermore*) The second category is not. It is only sensitive to the materials against which we might be competing.

375. I did not mean the second category; I meant the second example that you gave of the first category.
(*Mr Livermore*) The slight variant: it is less sensitive because we are talking about something that would have higher intrinsic value. It is a question of having a finished product and being able to gauge the real value in the market place.

376. With the present price of oil it is a "no-go"?
(*Mr Livermore*) Unless there were some other factor that forced people to use plant feed stocks rather than oil, you can forget about polymers from plants in economic terms.

377. If it were competitive, would it be quite a big market?
(*Mr Livermore*) It would be potentially enormous. Again, I do not have hard figures, but these materials are ubiquitous. They clothe us; they go into materials in our houses; they are everywhere in our lives. It is an enormous potential.

The Earl of Selborne

378. You say that if the economics were right, you might have produce on stream within five years. To what extent is the economics of the food crops—the wheat and the maize—a factor that needs to come right, bearing in mind that at the moment the value of those crops is determined by CAP support? If that were removed, would the economics be more likely to be aligned?
(*Mr Livermore*) That is a good question. Certainly, if we were to apply the same process to wheat produced in North America to that produced in the United Kingdom, the economics would be significantly different. If the CAP price were to be changed, it would have a bearing. On the other hand, if we are talking about largely wet fractionation processes, the raw material price is not dominant, although it is very significant. The simple answer is that it would make a difference, but how much difference I could not say at this stage.

379. In spite of the fact that the CAP is still there, prices have come down markedly.
(*Mr Livermore*) Certainly.

380. That must make the economics better than three or four years ago?
(*Mr Livermore*) Yes.

Lord Birdwood

381. What technological developments in resect of either growing or processing non-food crops are likely to be available over the next decade and how might those affect the competitiveness of particular non-food crops?
(*Mr Livermore*) There are two parts to my answer. One is that the technology that we have in-house already in our own centre, which is essentially wet fractionate technology on a pilot plant scale, is capable of handling cereal components and fractionating them into useful and valuable raw materials. That would need to be upscaled and commercialised, but it is relatively close to commercialisation. The other one that potentially could have greater impact and which is over a longer time scale is genetic modification. For these purposes, genetic modification is not being undertaken by Dupont in the United Kingdom. Work is being done in the United States, but, nevertheless, it could be applicable to Europe in the longer term. The kind of application I can think of here is the modification of conventional crops to produce high quantities of particular monomers and the production of high value polymers, something that cannot be done by conventional breeding, but could potentially be done by the techniques of genetic modification.

382. What was the driver in DuPont—please do not air any commercial confidences—in suggesting that this work was done in the United Kingdom at all?
(*Mr Livermore*) Which work?

383. Your work.
(*Mr Livermore*) That work was under way before we became part of Dupont. Until the beginning of last year we were part of Dalgety plc and we had already started that work.

384. How constant is your dialogue with your new masters?
(*Mr Livermore*) Pretty constant. If you are asking by how much it is directed from the United States, the answer is very little. We have a large degree of freedom in justifying our research programmes and in getting the funding to carry those on, if we can convince people of the benefits.

385. Have you been at all concerned with end-user markets for the results of your research?

Lord Birdwood *contd.*]

(*Mr Livermore*) To a limited degree we have talked so far mainly to companies in the food manufacturing area because that is essentially where we come from—the food industry. We have people who are potentially interested in the outcome of the technology. The philosophy is that if we have these materials and if we understand the properties, there are big opportunities outside the food manufacturing area. So far we have not seriously approached any manufacturing companies in that area. We know from academic contacts, who have alliances with other industrial companies, that there is believed to be a large potential and a large degree of acceptance.

386. Who will be the ultimate beneficiaries of the intellectual property that will be created in Cambridge? Will it be held within Dupont, or will it be shared around? Will this country benefit from your work first, or will the Dupont body of intellectual property be the beneficiary?

(*Mr Livermore*) The system within Dupont is that all intellectual property is owned by the parent company in America. Ultimately, it is the corporate body that benefits. However, the part of the company that is doing the processing is the first beneficiary and the first to report a profit. So, if we were to set up a wet fractionation plant, on a commercial scale, in the United Kingdom, it would be the United Kingdom company and the United Kingdom economy that would benefit directly.

Lord Walton of Detchant

387. Following up the points about technological development, obviously more will be said about GM technology, but we have been given evidence to suggest that there are mechanisms of selective breeding, both of linseed and oilseed rape; for instance, linseed, capable of producing a higher erucic acid concentration, which is used for lubrication as distinct from food. Do you see that kind of selective breeding as a major contributor?

(*Mr Livermore*) Certainly. Although I brought up the subject of genetic modification, it is not the answer to everything. No company with access to the technology would use it unless it had good reason to do so. Of the two alternative routes of selective breeding and genetic modification, I believe that you take the one that makes the most sense for that particular application.

388. One other piece of evidence that we received from the BBSRC was about the engineering of plant cells for the production of vaccines—a subject quite new to me—where it was said that the cost of producing pharmaceuticals in this way was likely to be much less than the cost of producing equivalent materials using fermenter technology. Are you aware of that work, and is Dupont involved in any way in the production of vaccines from plants and pharmaceuticals?

(*Mr Livermore*) I am aware of that. As you are probably aware, we have pharmaceutical interests, but to my knowledge we do not have an active interest in that line of research at the moment.

389. Again, we had evidence from the Scottish Crop Research Institute that cereal straw is being badly neglected as a potential source of energy and that there are now no facilities available in the United Kingdom for the pulping of such straw for producing energy productive materials. Is that something of which you are aware?

(*Mr Livermore*) I am aware of that. We see straw, not primarily as a source of energy, but as a wasted raw material that can be used in a fractionation process to produce high value ingredients, such as non-starch polysaccharides, such as waxes. I would agree with the waste of value, but I would not agree with the end use.

Lord Rea

390. Could you give us an idea of the use of the end products which are produced by the fractionation process?

(*Mr Livermore*) Certainly. You will appreciate that I cannot go into too much detail at the moment about those, but one possibility is to use materials extracted from cereal residues as a binder in composite boards. An example is medium-density fibre board, used in a whole range of products. It is bound using synthetic phenolic resins. If we can get the technology right, we could use a resin extracted from cereal residues to do that, or partly to do that job. That is one application. Another would be in paints, using materials extracted in essentially the same process, but in a separate stream. You could use film-forming non-starch polysaccharides as a body former in paints. Those are two clear examples for which I think there is already interest.

Lord Porter of Luddenham

391. I was a consultant for Dupont for many years. I would be interested to know how the feed stock used by Dupont for all manufacturing processes, from biological sources and plant sources, compared with the amount from mineral sources, and whether that is now becoming a larger part of the chemical business for Dupont?

(*Mr Livermore*) That is a question which I am not competent to answer at all.

Lord Rea

392. You mentioned that to start with that you will be closely associated with the food industry, but that the products that we are talking about are non-foods. How do you move from one to the other?

(*Mr Livermore*) When we became part of the Dupont group we had technology to produce ingredients from cereals which we saw as valuable food ingredients. Dalgety had essentially no non-food activities and, therefore, we had no real motivation to work in that area. When we became part of a company with large interests in materials, chemical processes and non-food products generally, we had a motivation to utilise the knowledge that we already had in areas in which we had not dealt before. Essentially, if you understand the rheology and other characteristics of a particular material, that knowledge is as applicable in non-food markets as it is in food markets. That was our starting point. We

then set up a dedicated team, of which my colleague is part, to look solely at non-food applications. So that was taking our current technology, our existing technology in food ingredients to be applied in the non-food area, but also to look more broadly than that and expand from our existing base into materials that might be solely for non-food applications. That programme is relatively new. It is less than a year since it was started and, therefore, we are not as advanced in that area as some other companies, I would guess. That is the direction that we have taken. On the technical level, the transition is a relatively minor one. Essentially you are dealing with the same functionality but with different applications.

Lord Walton of Detchant

393. To what extent do United Kingdom or European Union regulations restrict, or encourage, the development of non-food crops in this country? We have a good deal of evidence to suggest that there is, in a sense, almost a discrimination against non-food crops, under the existing European Union CAP system. We learned also that if farmers are cultivating a non-food crop on set-aside land, they have to lodge a substantial bond to make certain that the crop, when ultimately harvested, does not enter the food chain, but it takes two or three years for that money to be refunded. Would you care to comment on those points?

(*Mr Livermore*) That clearly discriminates against and makes it more difficult for farmers to enter that market. We have been very little involved with the supply side. As far as we are concerned, we can make use of crops which may be grown primarily for food use at the moment. I take the example of commodity wheat. We utilise particularly the lowest value residues from that to produce materials that could be both for non-food or food use. In that sense, we have not been particularly involved with factors that make the supply purely for non-food use attractive or not to the farmer.

Lord Middleton

394. Lord Walton asked about restrictions. Would your work be affected by any constraints that may be imposed by regulation in response to the public disquiet about genetic modification?

(*Mr Livermore*) For our work in this country on non-food crops there is no impact at the moment because we are not doing genetic modification. In the longer term, although these materials would not be entering the food chain, there is still a potential environmental impact to be looked at. It is something that could have an impact. It does not affect us directly at the moment.

Lord Soulsby of Swaffham Prior

395. Turning to international competition, earlier you said that in five years the technology would be such as to make developments useful Were you talking about United Kingdom technology or western technology as part of that international question?

(*Mr Livermore*) I was talking about our technology in the United Kingdom which could be applied anywhere. It could be applied in any continent, in any country. The factors that would influence where it was exploited would primarily be in terms of the end markets rather than the supply side. So we would expect to build a plant to serve a region where there was a significant demand. Once we had arrived at the stage of thinking seriously about that, there would be other factors coming into play, such as the support regime in certain countries and such as the encouragement by governments to build factories to do such things. We are not close to thinking about that yet, but obviously that will have an impact.

396. Compared with other countries, are we about level or are we behind?

(*Mr Livermore*) In terms of research, which is where I come from, we are well behind certain other European Union countries in terms of support for research in non-food applications. That is something that does not affect us directly as a company because we directly fund most of our research, but it will tend to reduce the number of people doing research and, therefore, ultimately probably make the number of firms producing commercial results smaller. So it is of some concern.

397. What will be the spur that will take us from the position that you describe to the leadership position?

(*Mr Livermore*) As we are talking essentially about something that is in the research and development phase, I think that some clear signal in terms of support for academic research would be a very good start.

398. Turning to the second part of the question about United Kingdom farm conditions, do those offer any advantage over farm conditions elsewhere internationally for the development of non-food crops?

(*Mr Livermore*) That is another area where I am not particularly competent to comment, but because we are dealing with crops that, at the moment, are grown for food use, that has not been something that has been a major issue for us. It could be for crops grown to be exploited purely for non-food uses, but we would see our technologies being applied to produce ingredients that could be sold into either food or non-food markets.

Lord Porter of Luddenham

399. What would you say was the attraction for Dupont to take over your company? Was it, as one hopes, that you have particular expertise, as one expects of Cambridge companies, or is it something else?

(*Mr Livermore*) It is a particular expertise. To put it in perspective, before Dupont purchased us, their customers in terms of seeds would be farmers. They were not in a position to move much further downstream than that. Within a three month time span they bought ourselves and a sister company called Protein Technologies International, both of which serve the food industry directly. They bought

Lord Porter of Luddenham *contd.*]

PTI primarily for market access as well as technology and they bought ourselves because we are essentially a research and development unit for the technology and for the intellectual property that we already had.

Lord Marlesford

400. Which countries in particular are you referring to as giving more support?

(*Mr Livermore*) I am certainly aware of Germany in that area. Perhaps Mairi Black can comment on other countries that she is aware of that support research.

(*Ms Black*) I attended a conference in Bonn where there were very few United Kingdom business groups. Most of the research presented came from European business groups. The research, compared with that going on in the United Kingdom, was quite well developed. Germany certainly was a main contributor, and Holland.

401. You are talking about government support?

(*Ms Black*) No, company and industrial support.

402. It is not that there is a differential in government support?

(*Ms Black*) European Union funding is available for these types of projects. Certainly we have been applying for European Union funding. How easy it is to obtain I am not sure because I have not been directly involved with that. In terms of the sponsorship, certainly there is more in European companies than in United Kingdom companies.

The Earl of Selborne

403. This is a little confusing. I understood Mr Livermore to say that the public funded research in this country was at a lower level.

(*Mr Livermore*) I believe that is also true.

404. I wonder whether you have any figures on that. We have had evidence from a number of sources, be it government departments, research councils, university groups or the like. I am not sure that we have a measure of what it all amounts to as it is difficult to quantify it. Have you any perception as to what the public funded work in this country is in total and how it compares?

(*Mr Livermore*) I am afraid not, but I could produce some figures for the Committee.

405. I dare say we probably have some of the information, but it is not something that I have here. You said that most of the work that your company is carrying out, including external work, is funded by your own organisation.

(*Mr Livermore*) Yes.

406. However, you are applying for European Union funding, presumably from the fifth framework programme?

(*Mr Livermore*) Yes, we are.

407. Presumably for that you have to have links with other countries in order to qualify?

(*Mr Livermore*) Yes, that is true. Mairi, do you know with which countries we are actively working?

(*Ms Black*) There are two or three German companies.

408. Do you also develop links within this country with other publicly funded research groups?

(*Mr Livermore*) Yes. There are a number, some of which we fund solely ourselves, so that they would not be in the public domain. However, we have particular activities starting under the LINK scheme involving Nottingham University and the Institute of Food Research.

Lord Marlesford

409. Is Dupont doing that sort of research in other countries?

(*Mr Livermore*) No.

Chairman

410. Mr Livermore, perhaps you can come back to us on the issue of public funding and the comparative climate for funding this kind of research?

(*Mr Livermore*) Yes, certainly.

411. That would be very helpful. On this point, I am not sure that I fully understand, from what you have told us, how far your work in Dupont has gone beyond the laboratory and out into the field. You are saying that you are five years from market. That would suggest to me that there is quite a lot going on out in the countryside, if I may put it that way. I am not getting that impression from you when we talk about supply and the interests of farmers or the viability for farmers. I am not getting a clear view. I would have thought that if you are only five years from market that you would have rather greater knowledge of all those issues than I have so far been able to extract from you. That may be a weakness of our questioning.

(*Mr Livermore*) No, it is probably our weakness in replying. We are relatively new in this area. Perhaps I can try to elaborate on where we are in terms of technology. We have gone beyond the laboratory, into pilot plant scale, capable of handling maybe 200 kilos of raw material and producing a few kilos of particular streams. It is the kind of scale that would then be followed by a small scale commercial plant. However, because we are new to trying to exploit the non-food area—and that is why we have a number of gaps in our knowledge—if you were to ask me that question in six months' time I could probably give you much more certainty about what the markets would be, what the likely timing would be, what the supply economics would be and so on. At the moment we have put together our technology with our rather limited knowledge of external markets. We have tested those with some industrial partners, through organisations such as ACTIN. We have tested those through contacts with academic organisations and we are confident that there are big opportunities, but we are probably being a little conservative by talking about commercialisation within five years because we do not have the really hard facts yet, but we should have those within a fairly short space of time.

Lord Nathan

412. What particular environmental or ecological advantages or disadvantages do non-food crops provide? I have the impression from what you have told us that the crops with which you are concerned are food crops that are not used for food and, therefore, it may not be in point to ask this question. We have had evidence and we have seen the products of non-food crops quite specifically developed for these purposes. Do the economic and ecological implications of non-food crops enter on your scene?

(*Mr Livermore*) Yes, but possibly not in the sense that the question was first raised. I think that the environmental and ecological advantages come further down stream in the processing. For example, in the more conventional route to non-food uses, which would be to provide feed stocks from plants for chemical processes, there is an obvious net effect in terms of not having to make such a use of extractive industries, a better balance of carbon dioxide and the usual arguments. That is one side. If we take the technology with which we are most familiar in Cambridge, one of the difficulties in the past with fractionation of materials has always been the disposal of waste streams. We are trying to, and I think succeeding in, using as much of the raw material as possible so that the waste stream is minimal. For example, you may take two or three soluble fractions from a cereal residue and be left with an insoluble cellulose fibre which also has a value. The effluent stream is then relatively minor and may have other uses, maybe as a fermentation medium. In that sense, compared with conventional approaches to the utilisation of crops for non-food uses, we see some environmental advantages.

413. You do not really see disadvantages?

(*Mr Livermore*) I do not see disadvantages.

Lord Rea

414. It is a cleaner process?

(*Mr Livermore*) It is a cleaner process.

Lord Walton of Detchant

415. Does the United Kingdom tax system act as a disincentive? We have been told, for example, that bio-diesel in many European countries is zero-rated for tax purposes, but it certainly is not in this country. Are there other fields where the present tax system is a problem?

(*Mr Livermore*) I am not aware of that. Certainly in fuels it is a major problem, but that is not an area in which we have an interest.

Chairman

416. Mr Livermore, perhaps I may conclude by asking what may be a slightly unfair or pointless question. I want to gain some feeling about how strategic this work is. You and I both know that companies and research institutions talk about exciting opportunities, five year time horizons and so on. Perhaps I may press you on whether you see yourselves as a sideshow or is this a serious business opportunity to which Dupont will commit a lot of work and money?

(*Mr Livermore*) That is a fair question. This is not a sideshow. This is a serious matter for Dupont. There is a business group set up in the United States to look at the broader commercialisation of these technologies. It is fair to say that because this is a relatively recent application of existing technologies, it is not seen broadly as high a priority as some of the major existing businesses there, but it is getting full support. As long as it delivers what we have said that it will deliver, it certainly will not be a sideshow.

Chairman: Thank you very much indeed and thank you Ms Black. We have asked you for one follow up point—the application of research funding regimes through the competitiveness of this activity in the United Kingdom. If there is anything further you would like to let us have in the light of the discussion we would be very grateful to receive it. Thank you for coming to give evidence.

Examination of Witnesses

DR KARL CARTER, Operations Director and DR TREVOR THEOBALD, Development Manager, British Sugar plc, called in and examined.

Chairman

417. Dr Carter and Dr Theobald, thank you for coming to give evidence. You have had notice of the kind of questions that we would like to ask you. As with your predecessors, would you be kind enough to introduce yourselves and say anything that you would like to say by way of introduction?

(*Dr Carter*) I am Karl Carter, Operations Director for British Sugar plc. British Sugar is the processor of sugar beet within the United Kingdom. More importantly, we are part of Associated British Foods and have been since 1991. Associated British Foods is one of the biggest processors of agricultural crops in the United Kingdom.

(*Dr Theobald*) My name is Trevor Theobald. I am based at the British Sugar Technical Centre, in Norwich. I am Development Manager and I am charged with looking at new technologies and new business opportunities that stretch British Sugar Group beyond its current range of activities.

418. Why is British Sugar interested in developing the technology for energy production from biomass?

(*Dr Carter*) The interest in British Sugar is that, as some of you may know, British Sugar is a large processor of agricultural crops—one crop, of course, sugar beet. That means that we have contacts with some 9,500 growers. Therefore, we have some significant expertise in buying; we also have significant expertise in high volume logistics. We process up to 10 million tonnes of sugar beet at our nine factories in a 20-week period. We are used to bringing in something like 5,000 vehicles a day. We

Chairman *contd.*]

think that is a significant expertise. More importantly, we have significant expertise in chemical engineering and in mechanical and electrical engineering and in the running of a very heavy engineering plant. In addition, we have significant chemical science and significant R and D within our business. We believe that that can also support developments. You may realise that sugar beet is a seasonal crop, harvested at the end of September and processed by the end of February. That means that as an operations director I have factories which do significantly less for 30 weeks of the year when they have the ability to process other material if made available to us. As a company we have a strategy to look at where the strengths can be used and hence our submission to the Committee.

(*Dr Theobald*) The only thing that I would add to that is that based on the evidence that you have already heard from Dupont, it is important that to make new crops and non-food crops work, core competencies need to come together that are able to process the crop at its various stages. On the evidence that Karl has given, British Sugar has put forward its core competencies.

Chairman: I follow your trucks up and down the Gainsborough-Newark road so I am well aware of the seasonality of sugar beet.

Lord Marlesford

419. Let us explore the question of energy, including the price of oil and its impact. Can you give us any feel for the level of the price of oil? The other half of the equation perhaps is the CAP support. I do not know how important such matters are?

(*Dr Carter*) They are very important factors. When you look at fuel prices at the pump today, you are probably looking at production costs of some 15 per cent. The rest of the cost being tax, VAT, etc. With production costs at that sort of level that means that if you decide to produce via a biomass, which is what we are looking at, clearly you are up against a very low production cost coming from oil. That is despite oil prices being around 16 dollars a barrel. We have to say that this new technology would be difficult, if you compared it straight with the production costs of oil. The new technology is likely to have a higher production cost than oil. Clearly, an important factor is taxation. We also recognise that with CAP reform and, therefore, the reduced revenue coming into growers from growing normal things like sugar beet, for instance, and also from cereals, then there is pressure on them to be able to produce other crops. Those other crops may be advantageous for biomass. CAP reform would help and taxation reform would make a significant difference in this area.

420. When you talk about other crops, do you mean the impact on the farmer whether he grows sugar beet at all between, as it were, growing for non-food use and, therefore, getting the set-aside money, but not the arable area money?

(*Dr Carter*) It would be very difficult to make a business making biomass for, say, bio-ethanol from sugar beet at the price we pay for sugar beat under the CAP. CAP reduction would mean that growers would grow things such as sugar beet and they will require less revenue for that and that would make the crops more competitive. It may not be sugar beet. I would not like you to think that this is all about growing more sugar beet for biofuel. That may not be the right biomass in the longer term, but it is one interest that we have.

Lord Rea

421. The next question was formulated with regard to a range of products, but we have mostly talked about sugar beet. Perhaps you would take the question to apply to a wider range of crops. What technological developments, in respect of either growing or processing non-food crops, or what level of support would be necessary to persuade United Kingdom farmers to grow non-food crops for biomass and energy?

(*Dr Carter*) Perhaps I can take that from the processing point first. Processing to bio-ethanol is generally via yeast, producing ethanol as you would for normal commercial brewing. That has been the normal method that has been used where you use a biomass, whether it is sugar, starch, etc. We have a particular interest in a new technology, which we believe has only just become available. That is not using yeast, but using bacteria. Those micro-organisms can break down a wider range of sugars. They break down simple C6 sugars, sucrose, glucose, etc, but they also have the ability to break down C5 sugars, e.g. Xylose. The difference with this technology is that the yield of ethanol from biomass may well be up to twice that of the conventional yeast fermentation. That would mean that you effectively have doubling of your yield from the same biomass. We believe that is a significant technical step. It would appear to be backed, as at the moment a plant is being built in Louisiana, in southern United States, and that will produce ethanol from a biomass. In that case it will come from the residual fibre from sugar cane, which is probably why we found out about it. Clearly, a 90 million dollar investment means that someone has the strength of their commitment to lay that plant down with that new technology. We feel that the new technology, and the step change that it is likely to make, will make it more interesting than it has been in the past. Coming to the biomass on farms, effectively your production plant is able to get twice as much ethanol from your raw material. Therefore, it will have an effect on the price. At the moment we believe that it will be difficult to grow biomass for ethanol using normal yeast technology because the cost of production and eventual revenue would make it a poor crop from the growers' point of view.

422. Where did you say that the bacterial processes have been tried on an industrial scale?

(*Dr Carter*) Louisiana. They are just building a plant at the moment. That has been made publicly available for about six months or so.

423. Could you tell us a little bit about the use of sugar cane derived ethanol in Brazil where I think this was used and is maybe still being used. I am not sure whether it was ever economical.

(*Dr Carter*) Very much so in terms of ethanol production. In Brazil the government have made it

possible for cane to be grown and processed in sugar factories but again it is yeast technology—so it is normal fermentation as we know it today for the production of ethanol—and then it goes into road fuel. They very much supported that programme. In fact, that programme has lost its support recently and anybody that follows world sugar prices will see a massive dip because of the Brazilians dumping sugar now rather than ethanol onto the world market so there has been a significant change. That technology has been around for a long, long while and we are now looking at a new technology which we believe will make a significant difference.

424. Is this something that you can be quite optimistic about?

(*Dr Carter*) We feel quite optimistic about the new technology, yes, definitely. We have in fact worked with a small company in the United Kingdom who probably have not had the funding to advance far enough on this, but have gone down the same line with a different organism, a different bacteria, but clearly they feel it is the right thing to do and they have gone down that particular line.

Lord Middleton

425. An ignorant question but you referred to the relatively quiet periods. Are the beet factories capable of taking in any other material from any other crop other than beet and then processing it?

(*Dr Carter*) A beet factory is effectively designed of course to process a root crop, sugar beet, and it generally uses water extraction. In fact, we extract the sugar; we do not actually produce it anyway, it is produced within the plant so it is an extraction process. As far as our factories are concerned because of the size of the units we have got, we have the ability to take in particularly root crops and to process them. We have particular technologies. The other thing we have at a number of our sites is very significant power plants and we have recently invested in a very large CHP power plant with a lot of available steam and electricity and that will put us in a beneficial position probably over and above others. If it came to a process that needed to be laid down we would already have part of the infrastructure and part of the power available to us. So sugar beet factories could at least be modified and if the crop were available outside of our processing season and it was a water extraction process then we would be able to undertake that as well.

Lord Nathan

426. Have you got in mind any crop which would serve the purpose that you have just indicated?

(*Dr Carter*) The one crop that we have looked at—I suppose this comes very near to sugar beet—is fodder beet. Sugar beet has been produced over the years specifically of course for sugar production where you require a white final product and therefore it has been used on that basis only. Fodder beet fed to animals has been produced for its yield and its yield of biomass is significantly ahead of the yield of sugar beet. From a processing point of view it would make very little difference to us apart from we would find it very difficult to produce white sugar from fodder beet. Clearly from that point of view it is an interesting biomass and we are doing further work on that. It also fits in very well with the previous question. If it were fodder beet we were processing it would be processed in the same way as we process sugar beet today.

427. What is the cropping period?

(*Dr Carter*) The cropping period would be the same.

428. It is not much good to you then.

(*Dr Carter*) But it can be stored outside of the norm.

Chairman

429. Is the traditional market for sugar beet going to survive the reform of the CAP anyway?

(*Dr Carter*) We certainly hope it will survive!

430. I deliberately put it that way.

(*Dr Carter*) The one thing that we recognise is that CAP reform and the reduction in the CAP will bring down the price of sugar significantly. It may also affect the amount of sugar beet that is grown because we are effectively capped by a quota system so we may have too many factories in the longer term if that were to happen, so from British Sugar's point of view we see a possible reduction in volume and we are a capped volume company now. We also see that our profitability will reduce as CAP reform comes through so therefore we are keen to look at what skills we have got in other areas.

Lord Marlesford

431. What proportion roughly of all the sugar produced in the world is used for non-food purposes?

(*Dr Carter*) Very, very little. The majority of sugar goes straight into domestic use and there is very little that goes into industrial. Brazil, as I mentioned earlier, is probably the best example of that. But saying that, the French in particular have had a drive for sugar beet being grown for fuel and they have been laying down around about 12,000 hectares of sugar beet for ethanol production for biofuel. Again, they have done it through taxation change which has made that happen. Clearly there are significant moves on the Continent.

432. For example, what proportion of the total French sugar beet production would that 12,000 hectares be, roughly?

(*Dr Carter*) Very tiny. It would be even tiny if I did it as ours. We grow in the United Kingdom 170,000 hectares of sugar beet. It would be a very small percentage and the French crop is probably three to four times greater than the United Kingdom crop. It is a very, very tiny amount at the moment, but again coming back to technology they use the yeast technology so again they are producing it and getting only half the yield they could do if they did it by the method we are currently investigating.

433. With this technology is there any differential in the economics of the production of fuel from sugar cane versus sugar beet?

Lord Marlesford *contd.*]

(*Dr Carter*) It will depend totally on the biomass total that you get. Clearly it is not possible to grow sugar cane in the United Kingdom because of our climate but, in fact, sugar beet in the United Kingdom is still a very high yielding crop. As I mentioned before, fodder beet is a very high yielding crop and certainly from a biomass point of view I think it would be very high in terms of biomass and would compare reasonably favourably with cane.

Earl of Selborne

434. That is exactly the point I wanted to raise. Looking at sugar cane grown on a plantation it does seem to me there is an awful lot of biomass compared to fodder beet, let alone sugar beet. Bearing in mind, as you remind us, that sugar prices (like most commodity prices) are extremely low at the moment, is there any natural advantage that beet has either for the production of ethanol or any other of these non-food uses over from sugar cane, apart of course from proximity to this particular market?

(*Dr Carter*) It is always difficult for us to compare ourselves with sugar cane. Sugar beet at its best in terms of production does not yield the same amount of sugar as sugar cane so it is always a difficult comparison and therefore sugar cane will always have that advantage, but clearly when you are moving highly voluble materials, bioethanol, there is the cost of moving and transport may make a difference. I am not sure, I cannot fully answer that question.

435. In some of the sugar cane research institutes around the world there is a lot of work going on presumably in parallel with your work and you must look rather enviously at them sometimes to see there they have got a perennial crop, admittedly it is difficult to harvest compared to sugar beet harvesting, but nevertheless it is an extremely low-cost unit. The only reason surely that sugar beet has been grown in Europe ever since the Napoleonic Wars is because it started protection in agriculture and has been going on ever since and could we realistically ever have had a sugar beet industry in this country had it not been protected for nearly 200 years?

(*Dr Carter*) You are quite right, we would not have a sugar beet industry in Europe had it not been protected. Saying that, the development of sugar beet over the last 200 years has made it such that it is still a high yielding crop on the farm today and in terms of biomass it still looks a very interesting crop in comparison to sugar cane. At the moment it is possible to yield up to, say, 12 tonnes of sugar per hectare from sugar cane. Beet at its best is around about ten. So although there is a significant difference, two tonnes on 12, you still have the problem of how to transport the sugar to this country. So it can be economical.

Chairman

436. In terms of those numbers and the point you are making about fodder beet, where would that come to?

(*Dr Carter*) We believe that fodder beet can almost double the biomass of sugar beet. The yield of fodder beet is something like 80 tonnes per hectare. Sugar beet in the United Kingdom is only 40 tonnes per hectare.

437. You are not offering a simple comparison of 20 to 12 on those numbers?

(*Dr Carter*) Fodder beet is not used for sugar production.

438. What therefore would be the biomass comparisons?

(*Dr Carter*) If it was a straightforward doubling effect between sugar beet and fodder beet then in biomass—

(*Dr Theobald*) I think in reality the biomass that you would get from the fodder beet would not quite be twice. You would perhaps get one and a half times what you would get from sugar beet.

439. And a comparison with sugar cane?

(*Dr Theobald*) I would imagine—and I have to say that I am speculating here—that it would be higher than sugar cane.

440. It would be?

(*Dr Theobald*) I believe it would be higher.

(*Dr Carter*) The size increase in yield overall.

441. That is what I was trying to elicit. Could you come back to us on that?

(*Dr Carter*) Yes.

(*Dr Theobald*) I think it is also very important to make the point that the discussions we are having today, although it may seem that they are very centred around sugar beet or fodder beet, really the driver around the use of these technologies is around biomass and we are at a very early stage in looking at these sorts of opportunities and therefore there may be other biomass sources that are more applicable than either sugar beet or fodder beet.

Lord Porter of Luddenham

442. Is all sugar production throughout the world subsidised?

(*Dr Carter*) All except Australia at the moment. Australia is the only country that does not have any support for sugar.

Lord Soulsby of Swaffham Prior

443. That is sugar cane.

(*Dr Carter*) And at the moment because of the world sugar price they are asking for government support.

Lord Rea

444. I wanted to take this discussion we are having a little bit further with regard to biomass, not thinking about deriving ethanol from the product but simply using it as a fuel for electricity generation. How would it compare with other biomass material that we have on offer such as short rotation coppicing?

(*Dr Carter*) I think it would be very difficult to compare the two. Short rotation coppice, given that

Lord Rea *contd.*]

it can get NFFO arrangements for electricity. With root crops such as sugar or fodder beet, it would mean starting from a vegetable crop with a high moisture content—

445. You have to dry it out first.

(*Dr Carter*) You have got to go right the way through taking your biomass and you are ending up with producing alcohol and then having to distil—

446. I said not using it for alcohol production at all.

(*Dr Carter*) You have got to get the biomass to a state in which it would be suitable as a fuel. It would be difficult to burn at high moisture.

Lord Rea: You cannot just burn the husk, the dry wood direct?

Lord Porter of Luddenham

447. The bagasse from the sugar cane is used.

(*Dr Carter*) Yes, it is a very high concentration with lower water volumes. If you take beet then you are looking at 75 per cent water so you have to evaporate 75 per cent water to get a dry product. At the moment we make that into animal feed so from that point of view we would lose our revenue from animal feed to be able to use it as a fuel.

Lord Marlesford: I was going to say that surely the main use for the biomass residue of sugar beet is in sugar beet pulp for feeding cows. I declare an interest as an owner of cows that eat sugar beet pulp.

Lord Walton of Detchant

448. There is in the submission mention that the refund scheme for sugar used in the chemical industry covers only about 1.5 per cent of sugar production. Do you think that refund scheme is adequate? Secondly, you have talked a lot about bioethanol, which is not supported by any specific support scheme, and we are told that sugar beet for energy can be grown on set aside but is not eligible for the set aside premium. Why not? Is that something we should take up with the Commission?

(*Dr Carter*) We certainly think that growing sugar beet on set aside would make a big difference and in terms of the tax position relative to sugar use in the industrial area, certainly if that tax were changed we think that sugar would go into more industrial processes. I guess that is specific to the use of sucrose within industry for going forward rather than what we are presenting today.

Lord Middleton

449. Turning to the question of regulation, firstly, to what extent is the development of non-food crops restricted by United Kingdom or European Union regulation and, secondly, to what extent is it encouraged? On the question of encouragement what should the Government do to help and to advance that technology excluding subsidies to growers?

(*Dr Carter*) It is very difficult to exclude the subsidies, of course. It is probably worth saying that there is significant support for biofuel production in the European Union. On 5 May this year the European Commission issued a paper providing details of the campaign for the take off of renewable sources of energy which you may be aware of. The main aim was to double the amount of renewable energy by the year 2010. Specifically within that White Paper the Commission has set a target of five million tonnes of liquid biofuels to be produced by this date and clearly at the moment we do not see that the United Kingdom Government has the mechanisms and regulation in place which would make that happen. So being able to grow on set aside, as in the previous question, would be an advantage. The tax advantage has to be the one that would make the significant difference, I am afraid, for this technology to move forward. With the low production costs from oil it makes it very difficult for this particular product and that would have to change if this was to go forward. In terms of where we would like to go we would like to see the United Kingdom Government providing a framework of funding to promote the development of these new and emerging technologies. We feel that would be the right way forward if the regulation were changed to be able to do that but we do believe that is for a partnership of both industry and academia to do that.

Lord Williamson of Horton

450. I am slightly coming back to one point. I am not sure that the sugar price is terribly relevant. Certainly during my career it has varied between £12 and £1,200 a tonne and that is a fact. On fodder beet what specifically do you need to put yourself in a position to encourage more people to invest in it?

(*Dr Carter*) You have made a very good point about sugar prices and therefore sugar beet prices, which go up and down tremendously, but in terms of fodder beet our view is that fodder beet has not been particularly looked at as a crop that may be able to be used for this type of work. Fodder beet has been progressed, of course, as what it says for fodder only and therefore we do feel that it is a crop that may have been left behind and the interest in pushing forward fodder beet has not been there. We do recognise that fodder beet is just one of the crops that may actually be available to go forward in this particular project. As my colleague said, we have looked at that in a little bit of detail. We have yet to look at other crops to see whether they compare. We certainly think fodder beet has been left behind. Sugar beet has been developed because a third of the world grows sugar beet so clearly there has been a lot of interest in that and fodder beet has been left behind.

Chairman

451. I think the second half of Lord Williamson's question was what specifically do you need to be looking for to bring it forward?

(*Dr Carter*) I think we probably have it partly within our own control and that is we need to look more at the agronomy of fodder beet and to see what type of yield might be available if it were grown in the same commercial way as we grow sugar beet today.

Chairman *contd.*]

I guess that is probably within our own control because we have agronomy within our own area which we may be able to put onto that and we may be able to do that.

Lord Birdwood

452. My question refers back a little. Where you come from, as you declared right at the beginning, was the need to exploit lazy assets during a low use period. Have you felt the need or have you applied the methodology of Life-Cycle Analysis to the production of ethanol from any of your beet categories?

(*Dr Carter*) The simple answer is no. Coming back to the lazy asset position, it would not stand in our way if we found that we could not utilise the equipment that we have within our factories so we have not put that as a total barrier. Of course, it would give us a massive advantage if we could, but if we had to lay this new plant down to be able to use this technology then we would also consider that.

Lord Middleton

453. We have had a lot of discussion about fodder beet. I think you produced it as an answer to using the kind of plant you have in your beet factories but is there any end product that you might possibly have in mind. Sugar beet produces sugar. What on earth would fodder beet produce at the end?

(*Dr Carter*) Fodder beet would go through biomass and would actually go through to biofuel. Effectively, it would be an ethanol. The nice thing about ethanol is that from ethanol you can go down further for the production of plastics, etcetera. It is basically a chemical Substrate of course and therefore gives you lots of avenues that you can follow.

454. So it is a dry matter that you are going to use in the fodder beet?

(*Dr Carter*) It is effectively a dry matter. It is either the sugar (because sugar beet actually has quite a high concentration of sugar) but also it is cellulose and C5 sugars and therefore the structure of the cell which you will also be able to use with the new technology.

455. So it is sugar and dry matter?

(*Dr Carter*) It is both and it is effectively trying to use the dry matter.

Lord Middleton: Thank you very much.

Chairman: The questions have been coming so thick and fast I have lost the plot a bit but I think it is Lord Soulsby.

Lord Soulsby of Swaffham Prior

456. Could we come on to international competition. I think you said earlier that two thirds of the countries of the world grow sugar beet.

(*Dr Carter*) The other way round. A third on sugar beet and two thirds on cane.

457. Coming back to this country then, do we have any natural advantages over other countries for growing sugar beet or fodder beet compared with other countries of the world, say the United States or Canada?

(*Dr Carter*) You have asked me to compare it to the States. Root crops such as sugar beet in the States generally yield lower than the European Union and within the European Union the United Kingdom is the third best producer. In other words, the yield of sugar per hectare in the United Kingdom is third best in European Union. So we have significant yields of sugar, in other words our climate, our soil types, our weather, etcetera, points to being able to produce significant yields of sugar. We do not think things like fodder beet are particularly different to sugar beet so therefore we think from that point of view our yields are likely to be on the high side. Saying that, we also have, we believe, significant differences in the United Kingdom. Farms tend to be much larger particularly in comparison to places like France and some of the other countries and therefore we believe that there is also the advantage of the economics of growing which would also come out. We do not see any reason why the United Kingdom cannot be competitive in biomass production overall.

Lord Walton of Detchant

458. If we are number three, who are one and two and why?

(*Dr Carter*) The French are number one, the Austrians are number two. The French are number one, one because their climate is better for sugar beet, to be honest. Their period of sunshine is much larger. Their soil type for growing sugar beet in northern France is tremendous and they do have some advantage of fairly large fields in the north. So they tend to be good producers of sugar beet. The Austrians have a climate that also seems to suit sugar beet, but we seem to be able to be as the Dutch and the Belgians and the other countries around there.

Lord Soulsby of Swaffham Prior

459. You mentioned earlier that we have a cap on growing sugar in this country. What about other countries, do they have caps?

(*Dr Carter*) Yes, every country in the European Union is capped by a quota system. So at the moment we are capped in terms of the amount of sugar beet that is grown because there is a cap on the amount of sugar that we can actually sell in the United Kingdom market.

460. That is for sugar beet rather than fodder beet?

(*Dr Carter*) Fodder beet is outside of that. Fodder beet produced for biomass, which is the one we are interested in, is outside of the reform. There is no cap on that.

Chairman

461. To what extent are higher yields a function of climate or agricultural organisation and to what extent are they a function of higher inputs?

(*Dr Carter*) Higher yields generally are because of soil type and weather conditions.

Chairman *contd.*]

462. In the United Kingdom is our relatively good performance dependent on a higher level of inputs?

(*Dr Carter*) The inputs on sugar beet crops are probably the same across Europe. The technology and the agronomy across Europe are similar so I do not think the inputs is a significant difference. It is down to the agronomy of the United Kingdom crop and I have to say a very professional growing community particularly on sugar beet.

463. Can I try and sum up purely for my benefit what I understand you are saying in this area which is that clearly sugar beet is under a disadvantage relatively to sugar cane, we know that, that is why we have a protected industry and so on and so forth. If we are moving across to looking at biomass as between fodder beet and sugar cane with the use of these new technologies that disadvantage may not exist or may be narrower, we are not quite clear until you produce the evidence, but what I am still not clear on is whether relative to other sources of energy you think these new technologies can render these sources of biomass ultimately economic in the United Kingdom?

(*Dr Carter*) It is difficult. We do not know enough. The new technology has not been available long enough for us to be able to establish exactly what the economics might be. We are encouraged by the significant increase in ethanol production per unit of biomass. Again, we still do not know which might be the best biomass. I have concentrated very much today on sugar and fodder beet basically because we are coming to that particular end in terms of factory usage.

464. We seem to be saying fodder beet rather than sugar beet but there may A N Other out there?

(*Dr Carter*) There may well be an A N Other out there which would be significantly better than fodder beet in which case we would certainly be interested even if we could not use the assets that are tied up with our sugar factories.

Lord Porter of Luddenham: A very short one although it may take a long time to answer. Why should the United Kingdom not rely on imports of renewable fuels? In answering that could you expand a little bit on this cap problem because you say we are all in the European Union capped on the amount of sugar that we can produce. Does this not mean then to get the sugar we have to import some of it or have I not understood it?

Chairman: Fodder beet is not capped.

Lord Porter of Luddenham

465. Leaving the fodder beet then, the sugar beet?

(*Dr Carter*) Effectively there would be no cap on fodder beet so we would have the ability to grow as much fodder beet as we required so therefore it is down to economics, could we pay a price for beet that was attractive enough against other crops effectively or against set aside if that was possible? Those are the comparisons that you would have to make in that particular area.

466. Why should we not rely on imports for these things?

(*Dr Carter*) I think my own view relative to imports is that if this technology can work in the United Kingdom why would we want to be dependent on others to supply fuel which I would take as being something that a country ought to have its own source of if at all possible.

467. So it is economical and sensible for us to produce it ourselves. Is that taking into account what the taxpayer does in subsidising it?

(*Dr Carter*) As I said at the very beginning, the tax position would have to change on biofuels to make this viable. Even with the significant increases in ethanol via this new method of production it would still be uneconomical to produce bio-ethanol without any tax advantage so therefore there would have to be a tax change to make this project actually work.

Lord Porter of Luddenham: Thank you.

Chairman

468. Thank you. There is a whole sequence of comparisons one has to go through here to get to the most viable biomass and then to decide whether the margin is such. You were saying that in the end the most viable biomass with the newest technology does not really make up the gap so there would have to be some other policy objective.

(*Dr Carter*) Yes.

469. Such as renewables.

(*Dr Carter*) Yes.

470. To render any of this viable in the long term anyway.

(*Dr Carter*) Yes.

471. But if that were case, you believe that of the crops we have been discussing fodder beet looks the most attractive?

(*Dr Carter*) It looks very interesting at the moment. Whether that will be the case in six months' time when we do more work on this, we shall see.

472. Thank you. We would be grateful for that further information you very kindly offered us. May I on behalf of the Committee thank you very much for coming and giving evidence to us. You can see from the heavy rain of questions how much interest your evidence has attracted. We are most grateful. I shall think of you warmly up and down that road in the winter season following the sugar beet lorries!

(*Dr Carter*) Thank you.

TUESDAY 29 JUNE 1999

Present:

Birdwood, L.
Hogg, B. (Chairman)
Middleton, L.
Porter of Luddenham, L.
Rea, L.
Selborne, E.
Soulsby of Swaffham Prior, L.
Walton of Detchant, L.

Examination of Witnesses

DR COLIN HARRISON, Technical and Operations Director of Uniqema, and DR SUE TOPHAM, Teesside Environmental Manager, ICI Technology, called in and examined.

Chairman

473. Welcome, and thank you for coming to give evidence to our inquiry. I understand that you are fairly familiar with the scope of the inquiry and you have had a list of questions to which the Sub-Committee will stick broadly, but only broadly. The questions provide useful headings under which we want to discuss a number of topics. Perhaps you would begin by introducing yourselves and your particular focus within ICI, and then make any other introductory remarks that you feel are appropriate.

(*Dr Harrison*) I am Colin Harrison, Technical and Operations Director of Uniqema. Uniqema is that part of ICI which is most heavily engaged in the processing of vegetable oils into specialist products. I am a PhD chemist and have worked for ICI for almost 25 years in R&D, manufacturing, technical service and business development. It may be sensible for me at this stage to update the Sub-Committee on the changing shape of ICI before Dr Topham introduces herself. The company is undergoing major restructuring and, in the process, non-food crops will become increasingly important to it. ICI is in the process of transforming itself into a producer of coatings and specialty products and, as a consequence, is divesting itself of its heavy petro-chemically-based businesses. In the future the new ICI (if I may call it that) will be based on coatings and specialty products. The business groups to which we may refer in our evidence, which are more intimately associated with specialty products, are: National Starch and Chemical, which is a world-leading producer of adhesives and related derivatives; Quest, which is a major producer and seller of fragrances and food ingredients; Industrial Specialities, which is the group to which Uniqema belongs, also contains; Synatix, which is a catalyst company; and Crosfield, which is a major producer of inorganic materials based on silicates. That is the grouping of specialty products. There is also the coatings group which focuses on decorative paints and coatings. Essentially, that is the new ICI which is very different from the company that I joined 25 years ago, or even the ICI of two or three years ago. The company is very much engaged in innovation driven by market needs. Our level of research spending as a percentage of sales is significantly higher than in the old ICI because of the markets in which the company now operates.

(*Dr Topham*) I am a PhD chemist, a Fellow of the Royal Society of Chemistry and a chartered chemist. I have worked for ICI for 22 years in a variety of roles: research, operations and new process development and technology transfer in places like the Far East. In the 1990s I was the environment manager for ICI's biggest operational site. For the past two years I have been involved in looking at strategies for sustainable development, including renewable resources. I am now the environmental associate in the group's corporate technology organisation. In addition to my role within ICI, I am a founder board member of the Royal Society of Chemistry's Green Chemistry Network and chair its sustainability task force as part of the Environmental Committee of the Royal Society. I am also on the board of ACTIN as ICI's representative. ICI was a founder sponsor of ACTIN.

474. Perhaps I may begin by picking up the point just made that non-food crops will become of increasing significance. Perhaps you can indicate the scale of that increasing significance.

(*Dr Harrison*) Our appearance before the Sub-Committee has made us do our sums on the new shape of ICI. If one takes into account the divestments that are announced, ICI produces both food and non-food products. Overall, after the current round of divestments about 50 per cent of our raw materials will come from renewable resources. Of that, about half—25 per cent—will be used for non-food products. That represents a major change from an almost totally petro-chemically based operation of even five years ago.

475. Can you give an idea of the implications for land use?

(*Dr Harrison*) Most of the products which we source in the non-food areas—I exclude substances like tallow and animal-based products—come from materials that are already in large demand and use as food sources. We are a relatively insignificant part, in most cases, of something that is used on a relatively enormous scale in food production. In terms of land use, we believe that even with our growth aspirations the effect on land use will be relatively minimal. Most of the products that we source are already in large-scale food production.

Chairman *contd.*]

476. To what extent do you source within and outside the United Kingdom?

(*Dr Harrison*) Interestingly, for vegetable-based material our sourcing in the United Kingdom, for a number of reasons that perhaps I should go into, is relatively small. As to Uniqema, its United Kingdom oil-processing operations are based largely on United Kingdom tallow. Because of the need to segregate animal and vegetable products, which has become ever more important in the past two years, our sourcing of vegetable oils in the United Kingdom is rather modest. ICI's processing facilities for vegetable oils are based largely in northern continental Europe. There is a burden on producers in this country to pay shipping costs for relatively low value materials into Europe. We source some rapeseed oil in the United Kingdom for further processing in Europe, but that is relatively small. If one takes starch, which is the other major element of our requirements, ICI's needs are pretty well met from enormous processing facilities in the corn belt of the United States and in Thailand for a tapioca-based route where we essentially begin with the vegetable material and process it all the way through into starch and a whole range of starch derivatives therefrom. Those starch derivatives are then moved around the world to be formulated into applications close to customers. That is how our market operates. When we add up what we purchase in terms of vegetable raw materials in the United Kingdom, the figure is very small indeed.

477. To return to product development for a moment, to what extent are changing attitudes to renewable resources a driver in this context?

(*Dr Topham*) We find that increasingly customers and consumers demand excellent performance at a cost-effective price, but they also look for a reduction in environmental impact. It is unlikely that they will pay extra for it but they expect that with excellent performance at reasonable cost. Given that trend, people talk more and more about renewable resources, and there is an almost automatic assumption that that means it is more sustainable. However, it must be recognised that that may not necessarily be so. The important things to consider in our view are what constitutes a sustainable way forward. One must look not only at the environmental but the social and economic issues. The environmental issues can be addressed with various tools. That can be done by a life cycle and environmental impact assessment, but the potential social costs are a bit more difficult. We have been working on ways to try to develop tools that may help us in that area. Over the past two years we have been part of a consortium of companies that has looked at what sustainability may mean ultimately in generating value to customers. That is not an easy job, and we are trying very hard to understand what it means. We are also founder members of the World Business Council for Sustainable Development. That body has been looking at guidelines to try to help with things like eco-efficiency and sustainable development. But there is no doubt in my mind that the issue of sustainability will drive consumers and customers in the future ever more, and we must try to understand what that means. Our research effort will be very closely targeted in that direction. For the past two years as part of my functions we have been trying to understand what this means. We have started on a journey, and we will not get there instantly. I am sure that that will drive innovation in future.

478. How does this change in consumer attitudes manifest itself? Do you make assumptions about what is going on, or is there clear evidence of it?

(*Dr Topham*) One has lots of requests from customers, both suppliers and down the chain, about our environmental sustainability credentials. That happened even in the old ICI when people thought that the company was quite a long way from consumers. Increasingly, one is being asked what are the company's environmental credentials. We have to develop tools so that we can try to make reasonable sense of these things, and that will help to drive innovation in future.

(*Dr Harrison*) In some segments one would expect customers to be aware of sustainability issues, for example personal care products. Where a marketing or technical claim can be made on the basis of sustainability there is considerable interest. When we talk to customers we find that there is a great deal of interest, albeit not a great deal of knowledge. We are very much leading each other forward in terms of what it may mean. But in the area of personal care there is a lot of interest; in others, when we speak to customers about it—certainly in my business—the attitude is, "My goodness, this is coming, but we do not quite know what to do. Can ICI help us?" We have a whole spectrum of attitudes. There are rapid advances in some areas, probably based on marketing rather than technical claims, and a struggle characterised by, "This is a horrible thing but we do not quite know what to do. It will change our whole way of working but, hopefully, not yet." We see those two sets of attitudes in our customers. That fits in very well with what Dr Topham said. It is a very difficult subject for us to get our minds round, particularly when customer perceptions and benefits come into it; and it is also a very difficult issue for our customers. When one comes to Life-Cycle Assessment, that is not an exact science. It may be data-rich, but it is rather difficult to draw conclusions from it. Like our customers, we are at a relatively early stage on this journey.

479. If this is an important driver of your product development strategy, are you taking the decision to go ahead to meet the changes in the market that you foresee, or do you respond to changes that have already taken place so that when people decide to buy personal care products they say that they prefer *A* rather than *B*?

(*Dr Harrison*) We are doing a bit of both. It is fatal to get too far ahead in the market. Many of us have done it and been disappointed by the uptake of our very clever ideas, which are highly sustainable. We have to lead by offering alternatives to what is currently used. That is a major thrust of our innovation. Radically new things may sometimes be a step too far, which is broadly our philosophy.

(*Dr Topham*) Some people look at this as a threat, but sustainability is an opportunity. If one looks too far ahead one may have a problem. However, one must be some way ahead so that one can anticipate

Chairman *contd.*]

events. Therefore, it is an opportunity. I have been engaged in environmental work for quite a time and it is something about which I feel passionately. These must be regarded as opportunities, not threats.

Lord Rea

480. Can you give an example of where you have been ahead of the market and an innovative process has proved not to be sustainable?

(*Dr Harrison*) There is one close to our hearts because both of us were heavily involved in it. I refer to the biopolymer Biopol (polyhydroxybutyrate) which was naturally sourced. Development started in 1977 and it was taken to a very large scale of manufacture. Golf tees and various other objects were made from the material. I hate to think how much each tee cost. At the end of the day the cost and performance were not there. It was a fantastic technical achievement which was totally sustainable. By conventional breeding we managed to get organisms which secreted more and more of the polyhydroxybutyrate and more high molecular weight materials of better quality, but at the end of the day the cost performance was not there. That is a classic example that is engraved on our hearts.

Lord Porter of Luddenham

481. I am delighted to hear that both of you are chemists, and have been for a long time. Essentially, does the great change in the form of the disappearance of the heavy chemicals and the emergence of renewables involve a change of personnel in ICI?

(*Dr Harrison*) It involves some change in personnel. Many of our scientists even in the old ICI have been working towards an applications-driven rather than a chemical properties-type culture. Therefore, there are some changes in personnel. For instance, technologists in heavy engineering will be needed less, whereas technologists in agile batch manufacturing will be in greater demand. Many of those people are able to make the transition; some cannot. If one looks at the net impact on research, which one thinks quite hard about, the R&D centres of many of the businesses described earlier—Quest Fragrances, coatings and so on—are based in the United Kingdom. That just leaves Quest Food based in the Netherlands and National Starch based in New Jersey which are outside the United Kingdom. Essentially, the research base and corporate technology function remain in the United Kingdom. There is probably a greater need for application scientists in the United Kingdom and less need for engineers, particularly heavy engineers.

482. Would those scientists include as many chemists as before? I am seeking words to reassure.

(*Dr Harrison*) I know exactly what you are looking for. Without going into it in great detail, I think that the position is broadly the same in terms of chemists.

Lord Middleton

483. Reference has been made to starch production worldwide and the worldwide activities of ICI. Do you see increased demand and therefore a growth in those operations?

(*Dr Harrison*) There will be some increased demand for starch but the ambitions that we have in that area are mainly for the higher value derivatives and further reacted products of starch rather than basic starch itself. Our considered view is that the impact on the volume of starch needed for our non-food and food applications will steadily increase but will have no major impact on the demand for starch globally. The thrust is towards the speciality derivatives of starch for the cleverer applications rather than the basic starches themselves.

Lord Birdwood

484. You referred to starch imported from the US and Thailand. What price do you pay?

(*Dr Harrison*) I am going to disappoint you because I shall not answer the question quite as you pose it. The issue is one of interchangeability of starches. Starch derived from potatoes or cereals in Europe is very different from tapioca or corn-based starch in the USA. Our whole product range, of which raw starch is a relatively small quantity, is based on the further transformation of those starches. It is not as simple as saying that if the price was right we would source potato starch from Europe for our starch-based applications. Our total pantheon of products has been derived for many years from starch based on corn, both the waxy and high amylose starches, and starches based on tapioca. We are not really in the starch business but in the starch derivatives business. One can argue that whatever the price, frankly, one would find it very difficult to process European-based potato and cereal starches. We buy very little starch in Europe. The product range is relatively sophisticated. We add the most value by further conversion of the starch into other products. All of our processes that do that are based on tapioca-based starch or mid-western products.

485. Is there any functional linkage in that sense between the decisions that you take and the highly regulated environment in which agricultural production is conducted in Europe?

(*Dr Harrison*) We argue that the issues which govern decision-making are the ones that I have already mentioned but that to manufacture starch from vegetable materials is, by our standards, a pretty capital-intensive process. It also depends on where one has the capital on the ground. We start from the historical location of assets. Those are the critical parameters on the basis of which our investment and sourcing decisions are taken. The regulated or unregulated nature of supply in Europe is not a significant issue in our decision-making.

486. Are there any by-products, or more specifically waste products, from your starch processes which themselves have commercial applications? I was thinking of your initiative in the recent past related to aerosol propellents and

Lord Birdwood *contd.*]

refrigerants. Can starch-derived waste be used in particular applications?

(*Dr Harrison*) Perhaps in a moment I can broaden the question beyond starch. As far as starch is concerned, obviously it is in our interests to extract the maximum value from every tonne of corn or tapioca that we process. We try to use as much of the waste as possible either as a fuel or animal feed, but there are some trace materials in starch. To come closer to my own expertise, in the area of vegetable oils sometimes these trace materials are economical to extract. The large agri-business companies particularly in the United States extract those trace materials from vegetable oils. I refer to vitamins like tocopherol and caroten. Those are extracted as natural products and compete against synthetic products very effectively. The demand now is for naturally-based products. There are other trace materials particularly in vegetable oils that can be extracted for gain. That is an area of interest to companies like mine. However, the structure of starch lends itself more to solid or syrupy rather than the gaseous or propellent-type products to which you allude. My colleagues in National Starch and Chemical always look for both waste products and further derivatives from starches to give novel effects, particularly those currently produced from petro-chemically-based products. For me, the better analogy is vegetable oil which is already an article of commerce. My own company and others seek to grow what hitherto have been waste products into viable sales of quite high value materials.

Chairman

487. Can cereal or potato starch be genetically modified to give the same characteristics as tapioca or maize?

(*Dr Harrison*) In theory, yes. Given the starch ranges with which we deal, we are considering two factors: the linear amylose and the branched components which give very different properties and application. Some of the difficulties of processing potato starch and the other vegetable starches, and comparing them in properties with tapioca or corn, are caused by that ratio. In theory, that can be done. In the corn area some genetic engineering and conventional plant breeding has been used to increase the amylose content. But there are other physical properties of starch, like the granule size within the plant, which also affect the end product and performance. Perhaps that may be a little more difficult to modify by any genetic engineering.

488. I realise that you do not have the comparative costs on the suitability of your particular process, but in terms of cost has ICI pressed for production refunds on European Union starch used for industrial purposes?

(*Dr Harrison*) No, we have not, largely because our purchases are extremely small.

Lord Soulsby of Swaffham Prior

489. What ICI non-food products are based on vegetable oils compared with mineral oils? What is the proportion currently? How do you see it evolving in future?

(*Dr Harrison*) Vegetable oils are very important feedstocks, in particular our lubricant product range products, aimed at the personal care market and our polymer modifier business. All of those are based largely on vegetable oils. Mineral oils are a very small part of that product range. The reason that we use vegetable oils in preference is that, first, there are some perceptual marketing issues in personal care. But the real reason is the technical effects that they provide and a sensible cost base. Almost all of the fatty acids produced by Uniqema are based on renewable resources and about 30 to 40 per cent are animal (tallow) based. The remainder are vegetable-based.

490. You referred to personal care products which at some time or other in their life cycle must be tested on animals for safety. Is it likely that both vegetable-derived oils will more readily pass the test than mineral oils?

(*Dr Harrison*) Certainly not. One might think so, as do customers. The policy of ICI is that there should be minimum animal testing. We do nothing except when it is mandated by regulations. Over the past five years we have moved as far as possible away from animal testing. Even so, testing vegetable-based materials and materials from other sources is broadly the same. The cost of new product registration and the introduction of new products is a significant block to making the change from conventional crude oil-based materials to vegetable-based materials. It could easily cost £ million to introduce a single new product just into the United Kingdom. There is some recognition of United Kingdom registration in Europe, but that can be the cost in just one region. Therefore, the regulatory burden is a significant inhibitor. Sadly, it is no easier to introduce vegetable-based materials. The regulators point out to us that the difficulty with vegetable-based materials is their lack of reproducibility because of seasonal effects in the growth of plants, and so on. Therefore, regulators argue that there is just as much need to test vegetable-based materials as crude oil or animal-based materials.

491. Can anything be done to reduce the regulatory barriers?

(*Dr Harrison*) ICI and other companies continue to make representations. Not only is this preventing us from introducing new products in areas of interest to the Sub-Committee but it is a major barrier to innovation and the introduction of new and better products, be they crude oil-derived or anything else. It is a distinct barrier to innovation in the United Kingdom, Europe and the United States.

Chairman

492. What can be done to reduce it?

(*Dr Harrison*) I believe that there should be a more transparent test regime in the European Union so that a single country's test regime can be accepted by

Chairman *contd.*]

others. Progress is being made in that direction but it is extremely slow. A greater difficulty is the transfer of test results from one continent to another, particularly from the US to anywhere else in the world. To get recognition of testing in Europe in the US is rather difficult. We are a global company and wish to introduce global products, as do our customers. The testing barrier is a problem. Some streamlined tests that we are working on with the regulators may also reduce the burden.

Lord Soulsby of Swaffham Prior

493. An European Union organisation, the name of which escapes me for the moment, is trying to get an overall agreement on animal testing and the replacement of animal testing. Are you co-operating in that?

(*Dr Harrison*) Yes, we are through our trade associations. That is quite an important issue. But beyond animal testing there are *in vitro* testing methods which themselves are rather expensive. There is still a need to unify those. We are working closely on that through our trade associations in influencing the regulatory authorities in Europe to do just that. But the struggle is a long one. The national test regimes are trusted by people of each nation and there is a great deal of difficulty and much technical argument required to unify those processes.

Lord Walton of Detchant

494. It is clear that your company is interested in the production of fatty acids derived from non-food crops. We have been told that oilseed rape which has a high erucic acid content is used mainly for industrial processes, but are you involved in both sides of the coin in regard to that crop?

(*Dr Harrison*) Our main interest lies in the conventional strains. One of our competitors has led the way in erucic acid for erucamide for lubricants. That is not an area in which we choose to compete. We tend to deal with the conventional variety. We are interested in rape as providing a fairly specific chain length and degree of unsaturation for the manufacture of our polymer modifiers, which is our specialism. We tend to specialise in the conventional rather than the high erucic varieties.

495. Who is your competitor?

(*Dr Harrison*) Croda.

496. Do you use any linseed oil; if not, why not?

(*Dr Harrison*) Very little. We find that linseed oil, given the degree of unsaturation, is rather unstable. We use it in paints and in other conventional applications, but given its chain length it does not find use in the more conventional applications compared with palm and palm kernel oil. Its high degree of unsaturation means that it is less stable. We have to hydrogenate it rather severely if we are to make it stable enough for our purposes compared with the conventional palmitic and oleic strains that we use. Linseed oil has promised much for many years but in cost benefit terms compared with competitors with similar chain lengths it has often flattered to deceive.

497. Many years ago on Teesside ICI invested rather heavily in single cell protein production for animal foodstuffs with bacteria cultures as the source. Is that technique still used for the production of industrial products?

(*Dr Harrison*) That technique is being used by Zeneca, the company that demerged from ICI in 1993. It is still used for food uses and some small volume of non-food uses.

498. Are the inputs purchased as commodities, or do you become involved in plant development, growing and processing?

(*Dr Harrison*) Unlike our competitor Croda with its high erucic acid rape, we buy pretty well all of our feedstocks as commodities on the open market because most of the things that we buy are materials that have very significant food applications. We are relatively small purchasers in that market.

499. I declare an interest as a former member of a working party on BSE which reported in 1980. From where do you obtain your tallow?

(*Dr Harrison*) That comes from the United Kingdom. It is probably the best regulated tallow. Our major tallow processing facility is in Bromborough in the Wirral. The vast majority of our high quality tallow is made in the United Kingdom, and it is also pretty cost-effective.

Lord Rea

500. Do you obtain a significant amount of your inputs in the vegetable oil field in Britain?

(*Dr Harrison*) Except for a small amount of rapeseed oil, we purchase very little vegetable oil in the United Kingdom. Our processing facilities for vegetable oils are in the Netherlands, Germany and Italy. We tend to locate most of our purchases in areas where we can ship to those locations relatively cheaply.

501. Is that governed more or less wholly by price or quality?

(*Dr Harrison*) It is governed almost entirely by price and the cost of shipment across a small sea channel which adds considerably to the price of what is a relatively low value material such as vegetable oil.

502. What can be done to shift towards United Kingdom vegetable oils from the regulatory or even technical point of view?

(*Dr Harrison*) For ICI the emphasis needs to be on speciality niche products that deliver particular benefits to customers. It may be specialised oils or even by-products from existing vegetable oils made in the United Kingdom. If they are already being supplied by somebody else a specialist chemical company with the marketing and applications expertise could use those materials and make money from them. It is hard to say what you can do against the cost of shipment across a short sea channel. That affects not only the vegetable oil industry but in a major way the petro-chemical industry in this country.

Earl of Selborne

503. One of the new ICI specialty product areas to which you referred was fragrances. Is this a growth area, or will it remain a niche product?

(*Dr Harrison*) In terms of the business it is an area that we have singled out for significant growth. In terms of its impact on non-food crops, I believe that it will remain a niche area because it is highly fragmented. A very large number of essential oils and plant-based materials are used by our fragrance business, but the fragrance business is to a large extent built around the marketing preference of large cosmetic houses and it is almost impossible to predict fashion trends. Therefore, as a supplier of fragrance ingredients we receive a proposal from a cosmetic house for a fragrance. It is then up to us to take whatever we have in our armoury and, fighting against our competitors, deliver that concept essentially. As far as we can see, the market will remain just like that. A very large number of possible materials are held to deliver what the market requires. As to its impact on non-food crops, rather like my answer in relation to starch, I suspect that it is rather modest and difficult for producers because it will be highly fragmented and unpredictable. If one wants an essential oil of a particular flower one probably goes to where it now grows in the world. It will momentarily distort the price as it becomes a major article of fashion and will then decline pretty quickly. In the past few years one has seen advertisements for jojoba oil as a fashion first. That seems to have gone into decline, much to the irritation of jojoba oil producers, particularly those who have invested heavily. Now teatree oil is becoming very much more important. The only place where it is grown on a large scale is Western Australia. These things come and go and our perception is that in terms of fragrances and essential oils the market is likely to remain as it is.

(*Dr Topham*) The quantities of these raw materials are quite small.

504. Presumably, each of these specialist materials has to be refined or processed in a specialist plant. You said that most of your vegetable oil processing capacity was on the continent, or certainly not in the United Kingdom. Is there any preferred geographical base for these fragrances?

(*Dr Harrison*) Because the scale is smaller they are relatively easy and cheap to transport, and they can be refined in most places in the world. For example, teatree oil is refined in Australia. The plant is treated and the essential oil is then transported across the world and further refined. That is the case with most oils. Transformation from a vegetable material to an oil is carried out local to production, rather like starch, and one has options as to where it is further transformed. One has many more options in the case of fragrances. We can refine those at our plants in the United Kingdom or in the Netherlands—or any of our plants in the world. We have multi-purpose distillation plants for those products.

505. We have spoken about vegetable oils, starch, tallow and fragrances. Are there any other non-food crops that come to mind in which the new ICI may be interested?

(*Dr Harrison*) We have thought hard about this. Nothing obvious springs to mind at the moment in terms of what is needed, but it is an area that we continue to look hard at. One must try to achieve a balance in looking at materials to give the performance at the right cost. There are many things available but not many of them give the performance that we require at a price that our customers can afford to pay. Our principal approach is to take the materials that are produced on a large scale for food and to transform those by clever science, or whatever, into speciality products. We do the downstream processing and add value in that sense. Although we are always on the lookout for new non-food crops, our philosophy is to use our clever science to transform existing food crops, or by-products from them, into materials that add value to our customers.

Lord Porter of Luddenham

506. You mentioned ICI's continued involvement in research, which has always been very great. What is your view about the current arrangements for handling communications between researchers, growers and processors? Are they adequate?

(*Dr Harrison*) Dr Topham as a member of ACTIN may be able to assist.

(*Dr Topham*) ACTIN has a role in co-ordinating and bringing together all the relevant parties. It does a number of things by various mechanisms. ACTIN has a database. The idea is that people should be on the database from a whole spectrum of interests, from growers to researchers to processors and end users. The database is up and running. ACTIN also organises seminars and conferences to try to bring together people who may be interested in new or existing non-food crops. It also acts to bring together people to put forward research proposals. I have attended quite a few conferences and have been impressed by the efforts. A good deal of what emerges is very much at the research end. The area that requires more attention is consideration of possible commercial implications. I have attended various conferences in Europe on the same subject involving other organisations. I am always very impressed by the great volume of research work that takes place on all kinds of things. For example, last week I attended a bio-plastics conference at which it was clear that all manner of things could be manufactured from all manner of natural material. That is very impressive. However, when one asks how much they cost and whether they are competitive with existing fossil fuel-derived materials often the answer is no, and sometimes by a factor of three or four. The research base is there but what is lacking is the need to think through how to take the best ideas and turn them into commercial successes. That is where industry must concentrate. We are always on the lookout. Continued involvement in ACTIN and organisations like that may bring some results.

507. Is liaison adequate?

(*Dr Topham*) One can always improve these things.

508. You say that it sticks at the researchers. Is it the fault of researchers or lack of liaison or organisation?

(*Dr Topham*) ACTIN is well aware of the issues. It is just a matter of working on it. When people think

Lord Porter of Luddenham *contd.*]

of new research proposals they are very enthusiastic and say that they can do this or that. That is fine. It is one thing doing it but to do it cost-effectively is another matter. Greater concentration is required on the latter.

Lord Walton of Detchant

509. We have heard a lot of evidence to suggest that in the field of non-food crops and food crops yield, purity, quality and pesticide resistance can all be improved by genetic modification. How important do you think these techniques are likely to be in providing the raw materials which have the necessary characteristics for industrial use?

(*Dr Harrison*) This is an area in which technology is developing extremely rapidly. We believe it is very likely that raw materials with the improved characteristics that you describe can emerge from developments in this area, as some already have. ICI like a number of other similar companies is interested in exploiting these material derived from molecular genetics or similar techniques, as long as the appropriate regulatory control is in place, which is essential. We are interested in using and exploiting those if they add customer benefit. The most obvious area for exploitation in ICI lies in an extension of conventional plant breeding. We have already touched on some examples of that. That is where the major impact has occurred to date. One takes what conventional plant breeders can do and extends it by some kind of gene expression work. For example, we have touched on the potentials of starch. There is the potential to secrete in a vegetable oil a rather high percentage of a very unusual, rare and valuable acid derivative. That would be a clear development. The implication of these developments for the vegetable and plant world will probably arise first in the United States or the tropics where plants most nearly provide the properties that are desired. Interestingly, the research work for that will be carried out on a worldwide basis, but predominantly in the United States and United Kingdom where the level of expertise in research is highest. But application will probably take place first in the United States. That has already started in the corn belt with the modification of soya and other varieties to produce different acid distributions. It will then be extended to tropical crops where there is much less genetic work to do to "improve" the plants to give them the properties that we require.

510. It is a good many years since ICI Pharmaceuticals became Zeneca. Do you have any contact with that company? We have had some information from the BDSRC that work is proceeding on the production of vaccines from plant sources. Are you aware of such work?

(*Dr Harrison*) I am not.

511. There is no form of contact any longer?

(*Dr Harrison*) No. The companies are separate.

Chairman

512. To reflect on your comments about the gap between pilot projects and commercial viability, does that suggest to you the need for reconsideration of the direction taken by research funding in the European Union?

(*Dr Topham*) The Framework V programmes recognises that issue. It is simply a matter of ensuring that that recognition is carried through and acted upon. One of the things on which it insists is that there should be industrial partners for these projects. These things are not perfect and need to be worked on. It is easy to get carried away and to think that we can do this or that. We probably can. However, whether at the end of the day it is cost-effective is another matter.

Earl of Selborne

513. Earlier Dr Harrison referred to the interests that ICI might have in assessing sustainability. I appreciate that most of the company's raw materials come from food crops, albeit used for non-food purposes, or residues from those crops. Nevertheless, is account taken of the environmental impact of the production systems, or because it is a waste product from food crops is that not something that is taken into account?

(*Dr Topham*) ICI has used Life-Cycle Assessment quite extensively for 10 years. We call it "assessment", not "analysis"; it does not warrant that scientific term. We believe that if there is any future development of non-food crops it is likely to be in niche areas. The effect on biodiversity and monoculture is likely to be much less than it would be with conventional crops. We do not believe that future development will give rise to a particular issue in that respect. But we use Life-Cycle Assessments. While we accept that it is not perfect and produces a lot of data which is often difficult to assimilate and does not address all the potential issues, for example social ones, we regard it as an excellent discipline that at least highlights where the issues may arise. We did a particular Life-Cycle Assessment under the aegis of CEFIC to look at surfactants made from renewable resources compared with fossil fuel-derived surfactants. We drew from it the valuable lesson that renewable resources are not automatically by right perhaps the best environmental option. The result was a degree of equivocation. It demonstrated that it was a complex situation and various raw materials had an environmental impact. It is a vital tool in highlighting and challenging some preconceived notions. As an environmentalist, I would welcome greater standardisation of the Life-Cycle Assessment techniques. We are very much in favour of anything that can be done to help promote that.

514. It is quite difficult to achieve traceability for feedstock materials such as starch and vegetable oil. You referred to tallow where your preference is to source from the United Kingdom because of the improved regulatory framework. Presumably, there is a need to have greater traceability than perhaps in the case of some starches. You have gone some way to achieve traceability. Can you imagine that being required for starch crops from tapioca, for example?

Earl of Selborne *contd.*]

Some agricultural systems are more benign than others.

(*Dr Harrison*) We are already required to give warranties about pesticide content for some materials. It is almost inevitable that traceability in both animal and vegetable products will be required. Traceability from lots of crude oil-based material is required. At the moment, for pharmaceutical applications we are required to provide traceability by lot as part of good manufacturing practice. I can see this spreading into the personal care area and ever more widely. Traceability is inevitable, but I cannot judge its pace.

Lord Birdwood

515. You have referred to the need for greater standardisation. We have already challenged witnesses about the highly subjective content of these models. What other business methodologies or techniques do you call upon to make investment decisions in the area non-food processing?

(*Dr Harrison*) If the Life-Cycle Assessment can be made less painful in terms of data requirements and lack of agreement on standards then that will provide a very good preliminary screen to decide whether or not the product is a potential winner. That needs to be followed by conventional cost benefit analysis. What does it do? Can we substantiate the benefit and effect? Our customers require us to say why they should change to something else. It is based not only on cost but on technical performance and benefit. To us, a conventional cost benefit analysis is the logical follow-up to a Life-Cycle Assessment. First, one has as Life-Cycle Assessment, and that is followed by: Can one make a business case for it? That is where we need to move with ACTIN in terms of transforming clever research ideas into something that can be used which can give customers benefits.

(*Dr Topham*) In addition to the environmental issues, one is concerned with sustainability. That places an extra burden on us to demonstrate over and above the Life-Cycle Assessment the social acceptability of the idea. I do not claim that I have methodologies for that, but we are working on it. We want standardisation, and I agree that that is the difficult bit. If we keep working with various organisations so that we are all going in the same direction we shall get there.

Lord Middleton

516. Let us return to the question of regulation and support. Dr Harrison has already told us about the high cost of registration, for example up to £$\frac{1}{4}$ million. In your paper you also mention the need for merchants and growers to lodge bonds for non-food crops, which may take up to three years to repay. Do those two measures apply only in the United Kingdom, or do they apply also in the European Union?

(*Dr Topham*) As to the first point, the registration costs apply in the European Union. I am not sure whether the second matter applies also in the European Union. I assume that it does given that the set aside issue is the same. ACTIN is probably the best body to ask.

517. Can you give any other examples of regulatory measures that make things difficult for you?

(*Dr Topham*) I understand that when ACTIN came here it was asked to provide a breakdown of all the relevant legislation that it believed existed. All members of ACTIN have contributed to that. I do not think that ACTIN has replied yet but it will do so very soon.

(*Dr Harrison*) We have already discussed our interest in two issues, the lodging of bonds and registration, which we believe to be a distinct blocker to any radically new use of non-food crops.

(*Dr Topham*) It must warrant the expenditure required to get started.

(*Dr Harrison*) We face this in our business daily with an interesting idea that customers may even find attractive. We have to set the opportunities against the costs of registration. Quite often, we may offer the customer something that is a little less effective because with conventional molecules we do not have to pay for registration.

518. You have referred to the market distortion caused by subsidies and set aside. Does that put the European Union at a disadvantage compared with your worldwide operations?

(*Dr Harrison*) What we look for as purchasers of raw materials is consistency. One has seen a lack of consistency in the set aside acreage and the rapeseed acreage which has gone up and down like a yo-yo. That has caused difficulties for us in setting long-term goals for the use of these materials. We are used to being on a bit of a rollercoaster in the commodity world of vegetable oil, but this has amplified the normal wide swings and has made the development of a whole raft of new applications of, say, rapeseed very difficult. If I say to my colleagues that I have some great news in that I have a wonderful new application for rapeseed they will tell me to wait for a bit and see what happens. That is an issue. Peripherally, as a company we have been involved in the manufacture of biodiesel at one of our units in France. We have seen that volume go up. Our plant can be occupied many times over in processing biodiesel for an agri-business partner and then suddenly become empty depending on the set aside acreage within a year. We know in about the autumn what the volume will be next year. The situation oscillates with that periodicity which means that we, who want a steady, fairly boring market in terms of sourcing our materials, are placed in great difficulties. That is one of the principal problems of a tax-based or incentive-based system.

Chairman

519. Before we leave the issue of registration, you have emphasised that the volumes are quite small. Am I right in thinking that there is a simpler, cheaper system of registration? If so, how many of your applications fit into that?

(*Dr Harrison*) Some of our applications do so. The regulatory system is defined perfectly logically. It is

relatively cheap for the first tonne, and up to 100 tonnes of absolute manufacture there is further cost but then it begins to escalate very steeply. Therefore, the system is based on 100 tonnes cumulatively rather than 100 tonnes per annum. One then gets firmly on to the treadmill of very significant expenditure and it becomes a real problem. The system is designed perfectly logically at the early stage and so it does not in that sense stultify innovation. But if one knows that one must cough up £ million from somewhere it must be a rather big application to merit it.

520. Does the volume that you use take you over the cumulative limit?

(*Dr Harrison*) Yes.

521. It is not so "niche" that you can continue to go under the wire?

(*Dr Harrison*) No. Eventually the evil day will probably come.

Lord Soulsby of Swaffham Prior

522. Do you regard taxes and subsidies as the most significant determinant in the production and utilisation of non-food crops?

(*Dr Topham*) At the risk of becoming boring, it is a matter of the performance of the product at a cost-effective price. That is the single most important factor.

(*Dr Harrison*) Taxes and subsidies might worry us. We have learnt the hard way that these things can change on a relatively rapid timescale given our operations and the longevity of a particular product. One looks to a product at least to repay the investment in research. One is looking for a minimum of five years with a major product platform based on non-food crops. If the rollercoaster has high periodicity it will totally distort the economics of the cost benefit analysis that one carries out and it will be an area of concern.

523. What action are you taking, if any, to modify the situation?

(*Dr Harrison*) We will make representations but since most of what we are talking about are food-based materials we represent a very small chunk of a very large market. We suspect that representations made by the food-based interests, and producers in particular—for example, matters like set aside—will tend to dominate the argument rather than our position as a relatively small percentage user of material for non-food uses. We may make representations as a trade association that life has become difficult for us, but tax incentives and so on are very much the bread and butter of the food interests. We believe that their views will always be given greater weight than ours.

Earl of Selborne

524. But in so far as you do not derive all of your materials from food crops and waste, would it not be sensible for you to insulate yourself from the vagaries of the Common Agricultural Policy by putting in place long-term contracts? After all, not everyone has to grow food on IACS-registered land. Surely, there could be stability which would be to your advantage and that of producers if five-year contracts could be arranged?

(*Dr Harrison*) Stability of volume is important but so is stability of price. Essentially, we are buying a commodity in most cases. We can be insulated in volume terms, but it is very difficult to produce a fixed price agreement for a commodity. The market price will almost always be related to a commodity price somewhere in the world. For example, coconut oil may be based on a Rotterdam spot price, and that formula will be applied by any grower to any contract that we may sign.

525. I should declare an interest as a past chairman of the Hops Marketing Board. We put in place inflation-indexed four-year contracts. That is perhaps a rather esoteric commodity that is used only by the brewing industry. All I can say is that, knowing that I had an index-linked contract and could plan my farm four years ahead, I was not terribly worried about the spot market in hop oil?

(*Dr Harrison*) That is a good point. In the case of a commodity like hops, which has rather narrow end-use applications, such contracts are relatively common, but with commodities like palm kernel oil and coconut oil, given the enormous range of food and non-food applications, to enter into such contracts with growers is very much more difficult. Growers will much prefer to have the benefits of the market. I guess that swings in price would be rather greater than in the case of hops. In this case growers would rather not insulate themselves from those vagaries and would want to take advantage of the "ups".

Lord Rea

526. What proportion of the material that we have been talking about might clever chemists like Uniqema be able to synthesise? I am referring to the niche, niche products such as the fragrance oils. Are you driven by the wish of the consumer to have those products, or is it much more economical to extract them than to synthesise them?

(*Dr Harrison*) In theory, the ingenuity of chemists knows no bounds. There have been many total syntheses from very simple molecules to incredibly complex ones. As far as our use of natural materials is concerned, nature has made some quite difficult things. The concept of making starch, beginning with glucose, is awe-inspiring in terms of complexity. To achieve by synthesis the acid distribution that one gets in, say, rapeseed oil would be incredibly difficult, beginning with simple organic chemicals or even—dare I say it—petro-chemicals. The reason we choose to use vegetable oils and starch is that the cleverness of nature means that we can get 98 per cent of the effect that we want. In the fragrance and vitamin worlds there are synthetic routes, but they are rapidly overtaken as we become cleverer at extracting these things from natural raw materials. For example, in the case of carotin and tocopherol there is a premium to be paid for naturally-based materials over and above their long, long developed synthetic counterparts.

Lord Porter of Luddenham

527. Is it true to say that the chemist could do it in almost every case but it is not worth it?

(*Dr Harrison*) Since the chemists have made ribonuclease, which is a highly complex protein, starting from almost nothing, what you say is true. However, in terms of cost benefit one shudders to think how much it would cost to do it that way.

Lord Soulsby of Swaffham Prior

528. You say that mother nature does it better than man. However, in the field of antibiotics and medicines, there are people who look for new molecules and identify their properties. Are you part of that scene? Do you tap into these often very small companies?

(*Dr Harrison*) Yes, to a limited extent, for example if in our personal care business we look for novel effects in skin care. We have looked at plant extracts in India. We have quite a powerful commercial interest in India. Such extracts have been used in Indian medicine for many years which have skin repair properties and are desirable in the cosmetic sense. We are always on the lookout for such materials which can be subject to the claim that they work or marketing colleagues in pharmaceutical houses can use them for marketing purposes.

Chairman

529. Dr Harrison, you have given us a very compelling picture of some of the drivers of your company in product development which is clearly important in this area. However, you have also given us a relatively clear picture that the demand for the commodity is outside rather than inside the United Kingdom. You have given the reasons for that. Can you pull together several factors? In judging the importance of some of these applications, it would help us to understand where these products happen to be in terms of regulation, agricultural policy and natural climate. Can you give us some feel for the likely demand for these commodities in the United Kingdom in this area given the industrial environment such as you have described where there is an increasing demand for these products?

(*Dr Harrison*) I have described the position of my company. Therefore, there must be an element of history in terms of assets on the ground which has defined where we are and our future view. We have made clear that the presence or absence of regulation is at best an irritant; it is not a major defining issue. My company is looking for high value applications, so in theory we should be insulated at least in part from commodity movements. The next issue is climate and what can be grown in Northern Europe. That is probably an extremely dominant issue in terms of sourcing. The principal vegetable oils that we source are coconut, palm and palm kernel. One then comes to olive oil, so one is creeping into the Mediterranean and there has been an explosion in the growing of rape which is a crop that is ideally suited to northern latitudes. We and our competitor Croda have used that to great advantage, for example in the production of erucamide. Genetic studies are going on in North America to make some crops secrete acid mixtures that look more like coconut. I believe that those plants exist in North America, but I do not think that as yet any economic application has been found. That approach may lead to an increased demand for vegetable feedstocks from the likes of ICI and Uniqema. I am not a climatologist, but unless there are negative changes in climates in tropical areas there will still be tough competition against entrenched producers of coconut and palm oil from Indonesia and the Philippines, for example.

(*Dr Topham*) I offer one comment that may assist. There is a project called IENICA. That has drawn together the experience in Europe and, more than anyone, should be able to provide that information. Do you have that?

Chairman: Yes. Thank you for giving us such full and thorough evidence in what is a fast-changing area. Your attendance is much appreciated.

TUESDAY 6 JULY 1999

Present:

Birdwood, L.
Hogg, B.
(Chairman)
Marlesford, L.
Middleton, L.
Nathan, L.
Porter of Luddenham, L.
Rea, L.
Soulsby of Swaffham Prior, L.
Walton of Detchant, L.
Williamson of Horton, L.

Examination of Witness

MR GAVIN GRANT, head of corporate communications, the Body Shop International plc, called in and examined.

Chairman

530. Welcome, Mr Grant. Thank you for coming to give evidence to this Committee. I am sorry about the small interruption. I do not know if you had a guided tour of the corridors while we were practising our fire drill. I gather you are slightly time constrained, as indeed is this Committee this morning, so with no further ado I will go straight ahead and ask if you would be kind enough, first of all, to start by introducing yourself and giving us any initial comments that you would like to about this inquiry. I think you have had a list of the kind of questions that the Committee will ask. There is not an entirely close correlation between the list of questions and what is actually asked but they will give you some flavour of where we are coming from. Thank you for coming, I gather at very short notice owing to your colleague's instant fatherhood.

(*Mr Grant*) Indeed. Thank you, Chairman. I should say, as a fire officer for the Body Shop International, I absolutely understand the sympathies of all on health and safety matters. My apologies. I have to give a television interview to the BBC lunch time news, in many ways slightly separate to your own discussion, but it is on the use of musk oil in the cosmetics industry and the WWF report this morning. Whereas the Body Shop has a strong tradition of using natural materials, hence our evidence to you this morning, I should say that we have always used synthetic materials and refuse to use musk oil for exactly the reasons highlighted by the WWF this morning. For the record, I am Gavin Grant. I am head of communications for the Body Shop International and I have worked for the company for the last six years. Very briefly, the Body Shop is known to many in this country but it is perhaps not known to all that we operate in 48 countries around the world. We are Britain's furthest flung international retailer and we operate 1,700 stores, so we have a great sense, not only of the regulatory requirements as they operate in this country and the opportunities that there are for the use of natural, agricultural materials in the cosmetics industry, but also the opportunities that exist elsewhere. The first question that was directed to me was what products does the Body Shop use. It is an extensive list and I will not waste the Committee's time in reading my way through it.

531. Could you give us some feeling of scale?

A. Yes. About 50 per cent of our materials are natural materials and a large number of those are drawn from the food industries. People will be familiar with some of the stories and legends of the Body Shop, our use of bananas, for example, which was a pioneering use. No machine as yet has been invented to peel a banana, so they are hand peeled in our factories. There are some very natural food materials in every day use through to some rather more obscure materials such as the argive fibre from the argive cactus, which is woven into use of scrubs for the company by the Nanu Indian of the Mosquital Valley of Mexico. That is one of some 40 community trade products and projects that the company uses. It is a very broad use. I would, if I may, however, draw your attention to one material which does relate to one of your other questions on regulatory constraints. That is the use by the company of cannabis sativa, industrial grade hemp. I draw it to your attention because it has been a matter of some controversy for the company. I hasten to add that this material, whilst of the same plant family as its more renowned cousin, does not contain the materials associated by some when they smoke or use the marijuana plant. We use industrial grade hemp because it is, of the natural materials, the highest that we have come across in essentially fatty acids. It is the replacement of the loss of those materials from dry skin, from the human body, as ageing takes place. We note with considerable interest that our hemp line is the fastest growing of our cosmetic materials launched in the last year or so. We also note with interest, and a little concern, that we currently source this material from France. That is a double edged issue for us, not least as when we launched the product in France we were the subject of raids in our stores by the French police on the basis that in some way, shape or form we were promoting the use of illegal drugs. Perhaps the French authorities have not quite got themselves aligned in the right way. We would like to source this material in the United Kingdom but we note the restrictions that are placed on the growth of this material in the United Kingdom which are stringent Home Office licensing requirements, which include such elements as that this material cannot be grown in public view and, even in minor roads or paths, must be blocked

Chairman *contd.*]

or obstructed so that the public cannot view the growth of a material which has at the moment 25,000 commercial applications, of which the Body Shop's usage is but one, and is recognised increasingly around the world. Legislative change has just occurred in Canada to enable the growth of industrial hemp. This material has very, very wide uses in the building industry, as a replacement for paper, in the decorative arts, in fashion. This Committee should be aware of, for example, such illustrious names as Giorgio Armani are using and experimenting with the use of hemp in the clothing industry. The original American blue jeans, Levi Jeans, were made from this material and in the automobile industry it is used by BMW, amongst others. That is a material that we use currently that we would particularly like to draw this Committee's attention to and its threat of use from this country because of the restrictions placed upon it by licensing; and indeed some question as to the level of agricultural subsidy that will remain in place on industrial hemp from the European Union.

Chairman: We have taken some evidence from hemp growers who are as exercised as you are about these restrictions.

Lord Marlesford

532. One of the things we are trying to get a feel for is the importance of non-food crops to British agriculture. It would be very helpful therefore if you could give us any figures for the sort of expenditure that you make in a year on non-food products from British agriculture.

A. It is very difficult to define that because the boundaries here are very blurred indeed. I am sure that has been the experience of this Committee. There are very few materials that we use which have almost no relationship to food agriculture and often they are natural products synthesised from the original food usage or they are a different application for food usage. As one comes down here to those areas which might be defined as non-food agriculture, you end up in areas such as lavender, for example. Our usage there is important to us but I am afraid rather small. I cannot give you definitive statistics at this point from the company. It is not an area that we break our purchasing into, as I am sure you can appreciate.

533. If you forget the source, is there any product that stands out as being of major importance in terms of your purchasing power over it?

A. None other than those which you would already be aware of in the food industry itself.

534. Would you say that actually, important though these products are for your many end products, they would be pretty insignificant in terms of agriculture in this country?

A. Absolutely.

Chairman

535. That would be true if you took the wider definition of non-food crops, crops used for non-food purposes, if you like?

A. It would.

536. Would you be able to give us a figure for that wider definition? I understand the difficulty in submitting that but a figure for your demand of the output of British land use, if you like?

A. I cannot, no.

Lord Soulsby of Swaffham Prior

537. Before going into the second question, I am intrigued by your 25,000 uses of hemp. Is there any reference that you can lead us to that would list these?

A. I believe that there is and I would be happy to attempt to furnish that for the Committee. We have undertaken an extensive degree of research in this area and I would be happy to provide you with that reference, if I may make a note of it.

Lord Soulsby of Swaffham Prior: If one can now go on to the products that you use, do these offer a technical advantage over conventional materials, which is the first part of the question, and secondly, are they used by you as an environmentally conscious image to use them?

Chairman

538. Which is the driver, I think is the question.

A. We have a preference for the use of naturally based materials. It is a source of inspiration for our company. It is a base that the Body Shop has built from and it is the inspiration by Anita Roddick and others of observing these materials in use around the world by the female population, where apparently "superior" synthetic products are not available. That is our heritage and we have discovered that in this wisdom there is much wisdom because the properties of these natural materials are more often than not aped by the synthetic as they are produced. There may be issues of stability around the natural materials and indeed of distribution and longevity, which is a problem our technical staff wrestle with. The answer is almost a little of both. It is the heritage of the Body Shop. As a company, we are committed to the sustainable agenda. We publish our performance against such indicators and I believe the reference normally is "warts and all", so you see that which we do well and that where we have room for improvement. We are committed to that area of work and as such the use of natural materials fits with that agenda.

539. One of the difficulties with natural products versus synthetic products of course is the great variation that you might get in natural products according to the conditions of growth, weather and so on. Is that a problem?

A. It can be for us. Clearly, there is a growing degree of market sophistication in the use of these materials. Often, perhaps rather unhelpfully from this Committee's investigations point of view, as these are byproducts of the food industry, there are very severe, as we know, and appropriately so, regulatory constraints on the purity and consistency of materials going into the food chain. We are a beneficiary of that regulatory framework and infrastructure that exists around it. Where it can be a

Chairman *contd.*]

greater difficulty for us is our desire to directly trade with communities in the majority world, where there may be far less understanding of the needs of an international business. There, we do engage a disproportionate amount of energy and technical effort to secure the consistency, quality and regularity of supply that we need as a business.

540. By the use of natural products, does this decrease or increase the need to do the testing of the basic products that you put into your end formulation, which has to be done of course. I am not sure what the regulations say at present, whether it is ten years prior to using them, but are natural products more readily amenable to animal testing, for example, than synthetic products?

A. As a matter of record, we do not test on animals; nor do we commission tests on animals. We use materials which have a proven history of safe human usage, materials which historically, under the regulatory requirement of the European Union's Cosmetics Directive, have required test data and where that information is regularly and readily available. With natural materials, certainly within the European Union, for the most part, because of their safe history of usage within the food chain, there is not a requirement for test data. It has to be said internationally this is not always the case and we have experienced some difficulty with food materials in countries such as Japan, for example. Again, it is a matter of some legend. Sadly, time precludes me from telling you of the Body Shop's trials and tribulations in introducing our rice brand scrub into Japan. Coals to Newcastle would have been a simpler task than that one. There is not a regulatory requirement as such for the testing of natural materials. In general, there is the assumption that their usage in the food chain does mean that their application within the cosmetics and toiletries industry would not require such testing or further safety data.

541. At no point in the use of materials for the cosmetic industry, even at the very beginning, are they assessed for safety in appropriate testing?

A. The European Commission's requirement, the European regulatory requirement, covers in essence three categories of materials, sunscreens being the most recent application, again partly because of the medical requirements of their original use, colourings and colourants, including hair dyes, because of absorption through the human skin, through the dermis; and preservatives. Whilst there are some debates about the possible usage of naturally based materials as preservatives, as yet, that science is fairly young. There, the Body Shop restricts itself as to the materials it will use and it will not buy a material from a supplier if that material has been tested under the European regulations or for other cosmetics purposes. In other words, the company will commission a test, and some have that presumption—particularly some of our competitors from the United States and the Far East, who are major players in the cosmetics industry—but we will not buy a material from a supplier that has been tested on animals after 31 December 1990, which means that we are fairly restricted in the materials that we can use, certainly in the field of preservatives.

Lord Birdwood

542. You have a commendable notice in your outlets inviting the public to bring back their containers. Have you a research programme going on for the replacement of polycarbonates for containers with novel materials that maybe depend more on natural products?

A. Yes. We have some early investigative work occurring here, looking at the possible use of sugar polymers in particular in that area. Again, part of our difficulty as a business, as perhaps I alluded to in my introduction, is the scale that the Body Shop operates here. We are in the early days of looking to manufacture in other parts of the world beyond the United Kingdom and to bottle and pot—no reference to hemp of course—in other parts of the world other than the United Kingdom. Certainly that is an area that we are very interested in. The mantra that the Body Shop uses is reduce, reuse, recycle, and we are keenly interested in the technologies which would allow us to reduce the impacts on the natural world as a company.

Lord Middleton

543. Mr Grant, you have told us that the Body Shop operates in 28 countries. Presumably your sources of supply are well spread worldwide. Could you give an idea of which countries produce your materials and, secondly, on what basis you choose your suppliers?

A. To be clear, we are in 48 countries around the world and it is almost as long a list of countries that supply the Body Shop as those in which we operate. At its most exotic, we source our brazil nut oil and babassu nut oil from the Meban Gokre tribe of the Middle Jingu area of Brazil through to perfectly straightforward commercial operations within the European Union and the United States. The list includes several areas of the mainland of Africa. We are, outside of the food industry, the largest purchasers of cocoa butter, for example, and that is sourced directly from a cooperative in Ghana with 4,000 farmers involved in that work through the intermediary of the Max Havelar Foundation in Holland. I am sure many Members of this Committee will be familiar with their work in fairly traded coffee, for example. It is an extensive list, alphabetically starting with Algeria and working its way through to Zambia.

Chairman

544. I trust you can describe the English tribes who supply you with equal precision.

A. Sadly, no, although we are undertaking work with the Physic Garden at Chelsea and through our foundation we are looking at some of the history and tradition of lavender growing in this country. Again, I am sure Members of this Committee may well be aware that, only a fairly short stone's throw from this House on the south bank of the Thames, lavender was extensively grown in areas which now might be rather more seen as Clapham, Balham and so on.

Chairman *contd.*]

Those were the lavender fields of London. The lavender girls selling the lavender on the streets—that is where they got them from. There were many different varieties of lavender grown there. We have funded some work through our foundation, examining how some of those species of lavender could be reintroduced into small areas of London and elsewhere in the cities. If that were to occur, that would be a source, as we would term it, of our community trade programme.

Lord Middleton

545. Of the non-food crops that you use, are there any that are best suited to growing here in the United Kingdom?

A. Clearly, there are some that could be. I have alluded already to one which could very simply be grown here in the form of industrial hemp. Many of the others are simply too exotic in their climate requirements. It would be a little difficult in commercial terms to reproduce the conditions of the Mosquital Valley outside Mexico City in the United Kingdom or the jungles of Brazil in the United Kingdom in a commercial sense. I failed to answer your question—forgive me, my Lord—on the conditions. For us, there will be two parallel operations occurring here. We will examine and do actively examine in the naturals field other sources, as we would define them, of communities in need where the Body Shop can source a material, through the transference of technology, through care and understanding, creative commercial initiative, often in association with some of the development charities both in this country and elsewhere that will sustain that community. I have given you some examples of that this morning. There has to be—and I should underline it—a degree of commercial viability about that process. We have experienced attempts for example to source birch bark boxes from communities in Siberia where sadly the Russian mafia became involved and it was not appropriate for the Body Shop to continue in that regard. We have other examples, handmade paper from Nepal, where our customers defined it as not a viable proposition. They simply did not expect to buy that from us, so that process could not go forward with the community in Nepal and we now source a lot of our decorations in our stores from that community. That would apply in that area. Outside of it, the issues would be ones of commerciality for us and exactly those that were alluded to a little earlier on of continuity of supply, quality, price and so on.

546. Presumably, the location of processing plants will be very important. I think we have heard evidence that hemp growing in this country is constrained because there is only one place where it is processed?

A. Indeed.

547. Presumably that kind of factor is important?

A. It is important to us as shortening the supply chain, as with any company operating on the scale of the Body Shop, is very important to us.

Lord Walton of Detchant

548. Are all of your natural products plant 1:1 derived or are any of them derived from animal sources? If so, which animals?

A. Yes, there are some derived from animal sources. The position that the company takes is that we will not use materials which are harvested in a manner where cruelty is involved to animals. Had I been before this Committee some years ago, you would have met me as director of public relations and campaigns for the Royal Society for the Prevention of Cruelty to Animals. I speak with some passion on this subject. Again, this can cause us some difficulty. For example, we have looked with animal societies around the world at how that definition might be applied. Materials such as lanolin, which is used extensively by the Body Shop, have been subject to examination, as to how we can ensure the efficacy of the husbandry involved in the production of lanolin and the care of sheep. Surprisingly enough—and again I would be very happy to reference the details for this Committee—that drew us to a conclusion that we should source our lanolin in South Africa rather than in this country. I would happily furnish the Committee with information as to how or why that decision was taken, given the large volume of production of wool in the United Kingdom. That is one example.

549. Not New Zealand?

A. Not New Zealand.

550. We would be interested to know why.

A. If that would be helpful to the Committee, I would be delighted to make a note and furnish you with that information. Bees' wax and honey are also used by the company. That decision was based on our commitment in community trade and we source our bees' wax and honey from Tanzania and Zambia and communities which farm the bees in a traditional manner in those areas.

551. Bees, of course, are not directly relevant to non-food crops but nevertheless that is interesting. It seems likely that the utility, quality, yield and consistency of the non-food crops will be improved by genetic engineering. How do you, in your organisation, view the use of non-food GM crops?

A. We have some concerns here. If I may specifically reference the unstated part of your question on food, the Body Shop has recently taken a decision to adopt the precautionary principle on the issue of genetically modified materials as our application of the food industry. For maize and soya, we have opted to move across to sourcing those materials from specifically defined GM free areas. I should say—again, of no surprise to this Committee, I am sure—that achieving that has been quite difficult for us due to the lack of knowledge of suppliers, often as to the end source. The middle man selling in the middle is not too sure where these materials have come from. We do have concerns here as to the possible long term implications of genetic modification, both within the food chain and outside of it.

552. If one looks at this as a point of principle, one must recognise that many so-called natural products carry considerable hazards not only in relation to

Lord Walton of Detchant *contd.*]

human allergic reaction but also in some instances due to a whole series of unforeseen side effects of the so-called natural products. May I take it from what you said that you are not opposed to genetic modification in principle in relation to non-food crops but you have some concerns about the possible long term consequences?

A. I think that is a perfectly reasonable summary of our position.

Chairman

553. Are you at this moment using any genetically modified crops?

A. We are in that unfortunate position simply as the degree of information that has been available historically has been poor. I should correct my answer and say we may be in that unfortunate position. Our suppliers have not been able to answer the question: does the soya oil purchased from the Body Shop through you come from a GM free source or indeed a genetically modified source? Their answer is the honest one that they do not know.

554. If you were to get an answer, you would stop using them?

A. What we have requested from our suppliers is that they move to a certified, GM free source for our materials.

Lord Porter of Luddenham

555. Is your motivation for this largely based on your environmentally conscious image or is it because you have real fears about GM crops?

A. With the Body Shop, what you see is what you get, warts and all. Our image and our reality we attempt to make the same, so our concern is a genuine one rooted in the potential environmental impacts. Also, some concerns as to how in the longer term ownership of the knowledge base of genetic modification and control of the provision of seeds and so on may impact farmers around the world, some of whom we work with very closely. There are some wider concerns here and we await in the request from government greater examination of these implications. For us, until we see that, we will sit with what we are comfortable with and request that these materials should be GM free.

Lord Williamson of Horton

556. Two questions, if I may. First of all, you mentioned the regulation on hemp. Are there any other regulatory constraints, for example, on oils like rapeseed oil or sunflower seed oil and so on which you think are not justified? Secondly, how sensitive are you to the level of subsidy? For example, the hemp subsidy is £500 a hectare and the cereal subsidy is £240 a hectare, so there is obviously a risk that someone might want to adjust them.

A. We are unaware of any other regulatory constraints that impact our business from that point of view, through the non-food materials supply. For us, clearly the degree of public subsidy no doubt is a matter of considerable interest. Its implications for us as a company simply reflect on the price of the material. In general, we have not found the price of natural raw materials prohibitive in any way from our desire to use them. They are an important component in our product and they are not sufficiently price sensitive to deny us access or to deny a product access to our customer base.

Chairman

557. I know we must let you go but may I end by asking you, from your excellent vantage point watching the change in customer sensitivities on this issue, how that has evolved over the period that the Body Shop as been trading?

A. There is no doubt that there is a growing desire for natural materials from customers around the world. It is not simply a reflection in this country. It is witnessed by the number of rivals and competitors, both as part of their offering to their customer base or in some countries—in the United States—you would find several stores that look remarkably like the Body Shop and I might gently say all of them have arrived on the scene after we arrived in the United States. There is a growing level of interest here from the consumer, both, I hasten to add, male and female. The largest increase in expenditures on toiletries and cosmetics as a percentage growth point is from the male gender rather than the female gender and both are set to expand considerably.

558. It is a load base problem.

A. Perhaps, but both are set to expand statistically substantially in the 21st century. This is a growth industry and interest in natural materials usage in this industry is expanding rapidly.

Chairman: Thank you very much indeed. If there is any further information you feel you could give to the Committee, we would be very grateful for it. Thank you.

WRITTEN EVIDENCE

Memorandum by ABI (Austrian Biofuels Institute)

BIODIESEL

Your inquiry on biodiesel (following a recommendation of Mr Peter Clery—chairman of BABFO), which I try to answer as complete as possible in such a desired short statement—key countries, in alphabetical order, production in 000 ton:

Country	*1997*	*1998 estimate*	*1999 forecast*	*taxation*
Austria	22	25	30	0.18 ATS/lt and zero by 1.1.2000
Belgium	20	30	?	no tax exemptions, exports
Czechia	45	55	60	zero taxation, plus lower VAT
France	250	260	250	zero taxation (quota 250.000 ton)
Germany	83	105	380	zero taxation for 100 per cent use
Italy	109	107	125	zero tax (quota 125.000 ton)
Sweden	8	10	18	zero tax (quota 30.000 ton)
USA	8	13	25	*

* USA: various legal and voluntary incentive systems and regulations (eg EPACT, Clean Air Act Amendment, Clean City Programme), etc—quite interesting:

Above figures are estimates following a detailed market research. We found in total 85 biodiesel plants of commercial background in as much as 21 countries around the world including Malaysia (palm-oil) and Nicaragua.

Please find attached as additional information:

- — the report "Review on Commercial Production of biodiesel World-wide" as the presently best source of information;
- — a brochure about the Non-Technical-Barriers Network for removing barriers to the development of liquid biofuels, as part of an activity in the ALTENER-programme of the European Commission;
- — a "Summary of Environmental and Macro-economic Benefits of Biodiesel" as compiled by the Austrian Biofuels Institute;
- — a copy of Mercedes-Benz "Omnibus Journal" in which the use of Biodiesel in MB-buses is described (sorry, only French version available) [not printed];
- — a brochure on "Renewable Energy in Austria" as a background information for you. [not printed].

Being quite familiar with the situation in the United Kingdom over the past years (as one founding member of BABFO) and willing to support any initiative to get biodiesel also going in the United Kingdom I suggest to arrange a workshop in which a small group of politicians, industrialists and biodiesel specialists can meet and develop a vision and a strategy.

BIODIESEL

An Environmentally Friendly Form of Renewable Energy
A New Liquid Fuel for the Transport and the Heating Sector

Summary of A. Environmental Benefits and B. Macroeconomic Benefits

Having observed lengthy and sometimes fruitless discussions over pros and cons of single properties of biodiesel as a new fuel the following summary tries to give a picture as complete as possible by compiling all the key differential advantages of biodiesel which have been identified in a number of in-depth studies on biodiesel in the past years in the European Union and in the United States of America.

Wherever possible those key features of biodiesel were translated into product advantages in comparison to fossil diesel which ultimately are resulting in an economic benefit for society.

In some cases a precisely defined price tag can be put to those benefits, in some other cases there is a clear indication of a financially measurable benefit but quantification needs further detailed work. With this compilation we hope to provide a number of arguments for more serious and balanced discussions about strengths and weaknesses of the new fuel biodiesel.

A: Environmental and Health Benefits

1. *Less Greenhouse Effect—Global Pollution*

The potential threat of a climatic change triggered by an accumulation of greenhouse gases in the atmosphere is one of the great concerns of our society today (lit. # 19) which explains the great interest in Biodiesel and the fuel's potential to contribute to a green house gas reduction has found all over the world.

Very detailed cradle-to-grave research within complete life cycle analysis has come to the following conclusion about the reduction of CO_2 and CO_2—equivalent gases (eg methane, N_{20}) when applying biodiesel:

Production of CO_{2eq} per 1 kg DFE (Diesel Fuel Equivalent = 42.7 MJ):

— biodiesel produces: 0.73 kg CO_{2eq}/1 kg DFE

— fossil diesel produces: 3.63 kg CO_2eq/1 kg DFE

In a nearly closed photosynthesis cycle CO_2-emissions of biodiesel are taken up again by the green oilseed plant which results in a reduction by 2.90 kg CO_{2eq}-emissions per 1 kg biodiesel in average. (lit. # 6.7)

Average costs for industrialised countries per ton of avoided CO_2 have been estimated with US$ 220 which translates into

avoiding CO_2-cost of US$ 0.64 per 1 kg biodiesel.

as calculated by the German Fraunhofer Institute in a study financed by the European Commission. (lit. # 17)

2. *Less Local Air Pollution*

Caused by the constantly growing traffic in urban areas air quality and hence life quality has deteriorated, specifically for health risk groups. Because of those risks various initiatives have been taken to improve the health situation of urban population, eg:

— the European Union Council Directive on Quality of Petrol and Diesel fuel (lit. # 18),

— the regulation and increasing restriction of certain harmful emissions (eg EURO 2),

— the Clear Air Act and related programmes (Clean City Networks) in the United States of America,

— the development of efficient exhaust emission treatment tools, such as the oxidation catalytic converter, or "oxicat".

On the fuel side biodiesel has an effect on the following emissions:

Type of emission	*Change of emissions for biodiesel compared to fossil diesel approx in %*	*Comments type of engine in test: modern EURO 2 with oxicat*
SO_x Sulphur oxides	−99	The new Council Directive for quality fuels has set a new limit of max 350 mg/kg fossil diesel. Biodiesel is meeting this requirement since the very beginning and has by nature only traces of sulphur of below 50 ppm.
CO Carbon monoxide	−20	
NO_x Nitrous oxides	+ 1	
NO_x *with optimised engine!*	−23	Substantial reduction by a 5° delayed injection adjustment
PM Particulate matter	−39	
HC Hydrocarbons	−32	
Soot	−50	Improvements up to three times under high load

Biodiesel has by nature an already "built-in" oxygen content of approx 10 per cent in the molecule which results in improved combustion and less emissions.

Above figures can vary according to engine type and test cycle. (lit. # 8, 13, 16)

Cost to society can be demonstrated by the example of the city of Paris (lit. # 20) where during a smog period in October 1997 all vehicles with even/uneven numbers were banned intermittently and public transport was free at a—cost of approx 1 million GB £ per day to the city budget.

3. *No Acute Toxicity*

Biodiesel as a natural plant oil derivative exhibits a low toxicity similar to food oil, ie in feeding tests on rats no toxic effect was noted up to the maximum possible feeding ration.

The toxicological results are, that the

— acute oral LD_{50}: is beyond 2.000 mg/kg body weight,

— acute dermal LD_{50}: is beyond 2.000 mg/kg body weight,

— (LD_{50}: lethal dose through which 50 per cent of a tested rat population die)

ie no toxic effects were observed. It has to be mentioned that fossil diesel contains poly-cyclic aromatic hydrocarbons of higher toxicity eg benz[a]pyren, which is considered to be a carcinogen (lit. # 21).

The benefit is that with accidental swallowing of or skin exposure to Biodiesel one can expect minimal health risks. (lit. # 1)

4. *High Flash Point*

The flashpoint describes the inflammability, ie how quick a fuel can catch fire during accidents or caused by carelessness. Fuels with a flash point of lower than 100°C require special safety equipment for transport and storage.

The requirements by fuel standards according to biodiesel—DIN E 51606 and fossil Diesel—EN 590 (lit. # 15) are for

biodiesel: >110°C

fossil diesel: >55°C

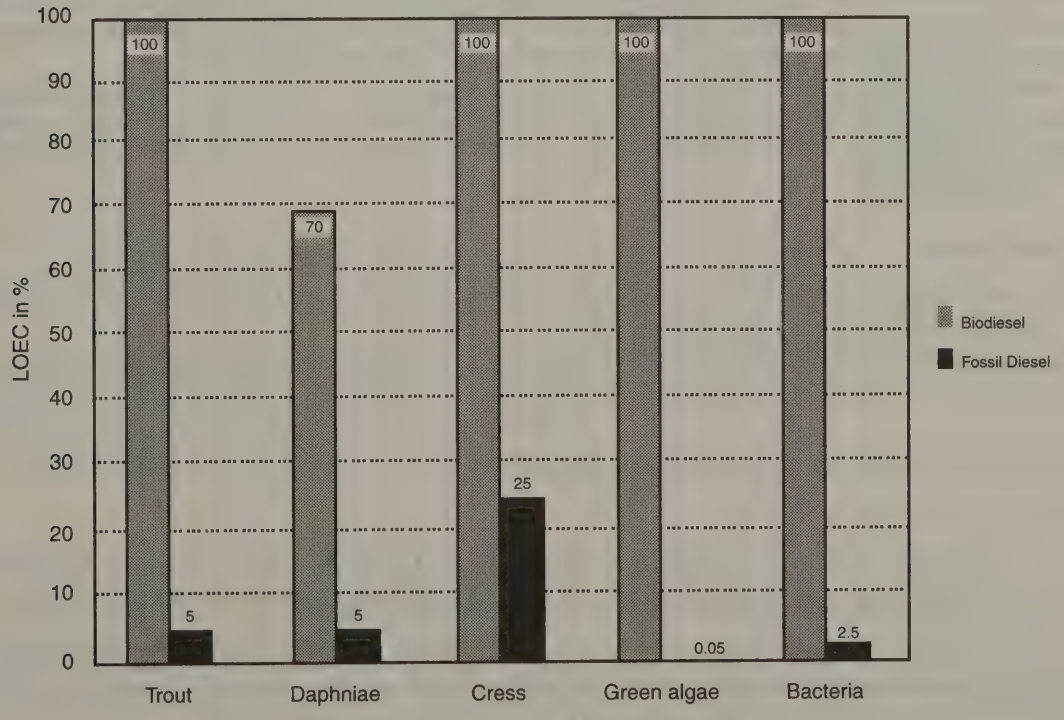
Due to the real flash point of up to 170°C biodiesel is by nature a very safe fuel and hence

reduces cost for security investments in transport and storage.

5. *Less Risk for Water Organisms*

In case of accidental spillage of fuels into open waterways damage can occur to water organisms. Comparative toxicity trials with biodiesel and fossil diesel have given following results:

Ecotoxicity



LOEC: Lowest Observed Effect Concentration in per cent of stock solution, when organisms show the first signs of being affected by a compound, eg 100 per cent of the stock solution with biodiesel has no effect on trout, whereas already 5 per cent of the same solution with fossil diesel has shown negative effects. (lit. # 3,4,14)

The benefit is that in case of accidental spillage of biodiesel into rivers and lakes the risk to fish and other animals and plants is significantly reduced.

This is correspondingly confirmed by the *German Water Hazard Classification* ("Wassergefährdungsklasse" = WGK) where biodiesel is in *class 1* and the more toxic fossil diesel is in class 2.

Latest research indicates a repositioning of biodiesel into WGK-class 0 in near future. (lit. # 5)

6. *Rapid and Full Biodegradability*

The degradation of a compound through microbial activity in soils is called the biodegradability. The result according to the standard test is for

— biodiesel: more than 95 per cent are degraded after 21 days,

— fossil diesel: about 72 per cent after 21 days.

Biodiesel as a natural product is perceived as a food substance by soil microbes. Although fossil diesel fuel is not considered as a very toxic compound its biodegradability is much lower and remaining residual (and more toxic) compounds have a much longer persistence in the soil. (lit. # 2)

The benefit is that in case of accidental soil pollution biodiesel is degraded rather rapidly by biological activity while fossil diesel on the contrary usually contains poly-cyclic aromatic hydrocarbons (eg benz[a]pyren) of higher toxicity and of much lower degradability therefore showing a higher persistence in the soil.

The risk for soil contamination is significantly reduced—as are the cost for decontamination.

B. Macro-Economic Benefits

Beyond the direct environmental benefits of biodiesel there are also significant macro-economic benefits to society such as:

1. *Fossil Energy Saving Effect*

Every applied litre of biodeisel saves 0,91–0,76 kg mineral-oil as a finite source of fossil energy, ie, it extends the possible utilisation of valuable mineral oil sources for later years and for more important usage than just burning. (lit. # 6) Certainly mineral oils will not decline in value in the coming years.

While there are efforts to switch more and more to renewable forms of energy are continously increasing world-wide the financially quantified benefit of the factor renewability (eg, as a factor of increased energy supply security) is not fully explored, but most probably represents the by far leading benefit above anything else.

2. *Energy Balance*

Evaluating energy input for biodiesel production versus energy output the energy balance for biodiesel is:

positive with an input-output ratio of 1 : 3,23

ie, for one energy input biodiesel produces 3,23 units of energy output—as biodiesel is one form of free solar energy which is stored by the oilseed plant. (lit. # 16)

3. *Strategic Cost to Assure Security in Energy Supply*

Example United States of America:

More than 60 per cent of known mineral oil reserves are located in the politically unstable area of Near East. The needed presence of strategic forces on the spot is a cost directly related to the protection of mineral oil supplies from there.

A strategic study (lit. # 12) evaluated all these costs of generating and sustaining United States military forces in peacetime in the Persian Gulf with US$ 60 billion which in relation to total United States imports of 6.2 billion barrels (1992) result in:

United States national security cost of US$ 9.70 per barrel mineral oil.

This cost is a daily fact to the United States tax payer—it is however not paid at the fuel station pump but out of the general public budget with no transparency at all to the United States citizen and diesel fuel customer. (1 barrel = 159 litre)

4. *Employment Effect*

Example Germany:

In a recent input-output study of the IFO-Institute in Munich/Germany (lit. # 9) evaluating the macro-economic impacts of a 300.000 to/year biodiesel production resulted in a:

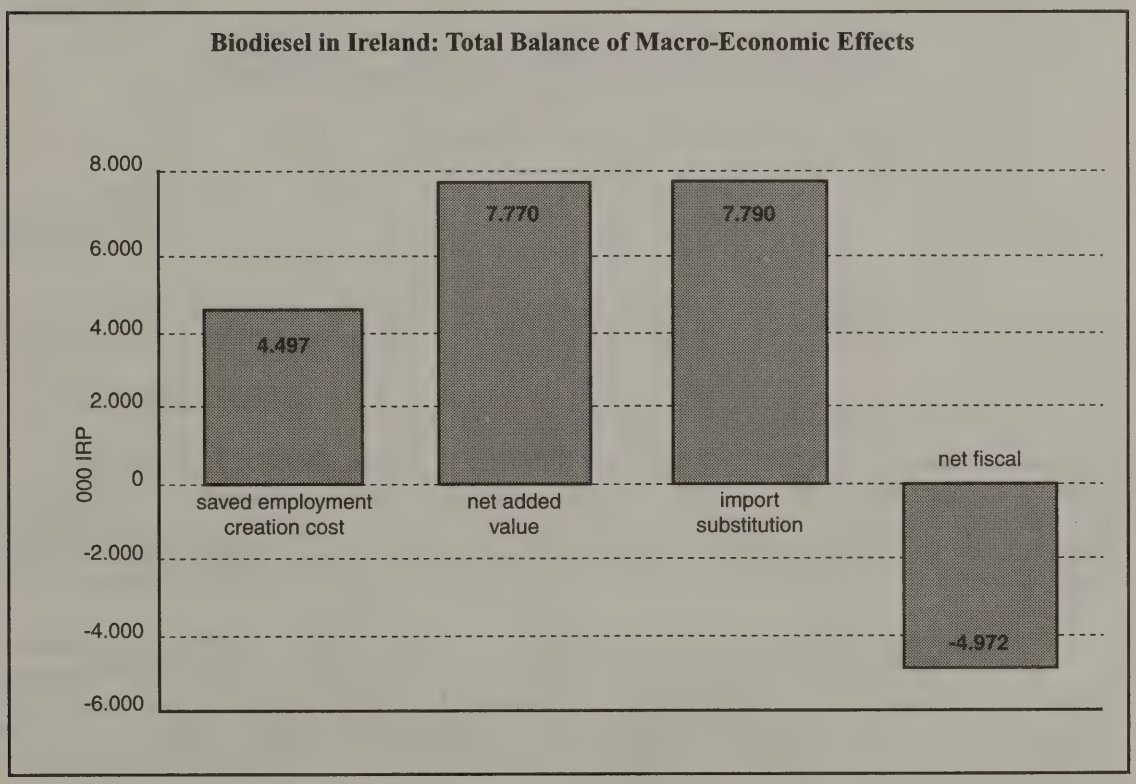
— total employment effect for 4.830 employed persons.

These jobs are located in rural areas, in the industry and in the trade—mostly in small and medium sized enterprise as the key motor of any national economy.

5. *Impact on Macro-Economics*

Example Ireland:

Domestic production of biodiesel reduces costs for energy imports at the same time as it saves protein meal imports. Furthermore the effect on the national gross product is positive due to a better valorisation of domestic resources. (lit. # 10, 11)



Biodiesel saves employment creation cost for 324 persons (assuming 30.000 to of biodiesel production) thus saving the state budget 4.5 million Irish £.

Assuming full detaxation the total balance ends up with:

a benefit for the state budget of 15.0 million Irish £.

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Werner Körbitz

1 April 1999

Memorandum by ACTIN (Alternative Crops Technology Interaction Network)

Introduction

1. ACTIN is an industry-led initiative whose mission is to promote the sustainable production of oils, fibres, starches and speciality chemicals as renewable raw materials for industry.

2. It was launched in 1995 in response to an initiative of the National Farmers' Union and the Biotechnology and Biological Sciences Research Council (BBSRC). In the same year interest in non-food crops was reinforced by the POST report "Alternatives in Agriculture". The Foresight panel Agriculture, Natural Resources and Environment also highlighted this as a priority area for the future. The inclusion of *Crops for Industry* as a key topic in one of only ten panels in the second round of Foresight strengthens this view.

3. ACTIN has strong links with industry. Its principal sponsors currently include companies such as British Sugar, Cargill, DuPont, ICI and Zeneca. Its Special Interest Group, ACTIN^{2020}, has other multinational companies including Danisco, Dow, Schlumberger and Unilever as members, as well as an increasing number of small and medium size businesses which fulfil important roles in the supply chain. This area of technology has been specifically highlighted by the Chemical Industries Association as a, perhaps the, major long term opportunity for the chemical industry.

4. ACTIN's main activity is " networking" between and within industry and academia. Its principal field of operation is the United Kingdom, where it is now recognised as the focus for activities in the alternative crop arena, but links with Europe are developing under the IENICA (Interactive European Network for Industrial Crops and their Applications) and ERMA (European Renewable Raw Materials Association) initiatives.

What is the potential for the development of non-food crops in the United Kingdom? Which crops, if any, are likely to prove significant in terms of economic activity or land use?

5. The potential markets for renewable raw materials are significant and global. For example, Surfactants, many of which are already based on vegetable oils, have a world market of £7 billion and the European potential alone for biodegradable lubricants is over £1 billion. However, apart from traditional uses such as vegetable oils in soap manufacture, starch and non-wood fibres in the paper industry, the market is immature. There are poorly developed supply chains, and manufacturing processes which can utilise crop-derived raw materials cost effectively need to be developed.

6. Global production of crop derived materials for industrial use is estimated to be in the region of 51 million tonnes, valued at £20 billion today (see Appendix 1). Of this, UK production represents a modest 360,000 tonnes. Actual penetration of the gobal potential is however minimal.

7. Manufacturing industry recognises the benefits of crop derived products as raw materials in that they are more sustainable in the long term than non-renewables such as mineral oil, they are non toxic and biodegradable. However, such materials must also be competitively priced and available in sufficient quantities to meet market needs in addition to matching functional specifications. One opportunity being investigated at the present time is the use of oilseed rape oil as a low cost feedstock for the polyurethane industry. However, in most market sectors current low oil prices make competitive pricing difficult and improved supply chains need to be put in place to reassure industry of raw material availability.

8. Environmental and consumer considerations, as well as cost drivers, are focusing increasing attention on crop-derived products as a source of sustainable raw materials by an increasingly diverse range, size and spectrum of organisations. This trend will continue to drive the development and increased utilisation of such materials in the future.

9. Given this trend it is anticipated that the global market will grow from 51 to 71 million tonnes, valued at £28 billion by 2003: a growth of 39 per cent (see Appendix 2).

10. United Kingdom is well placed to benefit from this market growth. It has a strong research base to provide the necessary technological improvements, a productive agriculture capable of producing raw materials at competitive prices on the world market, and a forward-looking industry which recognises the potential of crop-derived products. ICI's recent acquisition of the Unilever Speciality Chemicals business comprising National Starch (starch products from maize and wheat), Unilqema Chemicals (oleochemicals from oilseed crops) and Quest (flavours and fragrances) is a prime example.

11. The United Kingdom science base has:

— wide-ranging expertise underpinning *all* the major market opportunities;

— skills ranging from basic agronomy through to economic and life cycle assessment; and

— an extensive research programme in oils, fibres, starches and speciality chemicals.

12. Broad acre crops such as wheat (for starch) and oilseed rape (for oil) are likely to account for the main land use. Yields of these crops in the United Kingdom are the highest in the world and, although labour and other production costs are also high, the unit costs of production are competitive.

13. The fibre crops, flax and hemp are currently supported by significant area payments under the Common Agriculture Policy. However, improvements in yield and processing efficiency should, in the medium term, enable these crops to remain competitive with imported fibres such as jute even when the anticipated reduction in area payments occurs. New uses for these crops, such as in the automotive industry, are also being developed.

14. Specialist crops such as borage and evening primrose (both grown for gamma linolenic acid production) and herbs such as lavender, rosemary, camomile etc will continue to meet an increasing demand in high value niche markets.

15. New crops including woad (for natural indigo), calendula (for calendic acid), camelina (for eicosenoic acid) and crambe (for erucic acid) are currently being developed. Some of these will require significant land area (10,000 ha plus) and will add to biodiversity on the farm.

16. Existing food crops such as oats, peas and potatoes are being investigated for their ability to produce novel starches for non-food use with unique applications.

17. Crops are also being developed for the production of special, high added value, bioactive molecules for use as agrochemicals and pharmaceuticals. For example, research is being carried out into the production of phermones from *Nepeta* (cat mint) and vaccines from potatoes.

What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg by the genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability be overcome?

18. Major market opportunities and potential applications fall into four main areas—chemicals, speciality chemicals, industrial fibres and industrial oils. Examples are:

— chemicals: polymers and plastics, dyes, paints and pigments;

— speciality chemicals: adhesives, agrochemicals, pharmaceuticals, personal Care Products, soaps and detergents, specialised organics;

— industrial fibres: paper and board, composites, textile fibres, bulk fibres;

— industrial oils: two cycle oils, transmission fluids, lubricants.

19. Usage of crop-derived materials for all these applications is driven by a number of key factors: These include potential improved performance of the resultant products, their sustainability, their low "cost of use" (including the cost of raw materials, processing and waste disposal), politics, consumerism, the green movement and global climate change—all crops covert CO_2 into oxygen and a range of plant storage products—carbohydrates, lipids and proteins—thereby mitigating the effects of global warming.

20. To realise the full potential of plants and their products, a number of technologies will need to be employed in their chemical, physical and/or genetic modification to achieve consistent and reliable reproduction of molecules and polymers designed to meet industry's—and, therefore, the market's requirements. Chemical erngineering and process engineering will need to be employed as well as genetic engineering. Existing plant products can be modified by the former, but biotechnology, employing a combination of conventional plant breeding and DNA technology will enhance plant productivity and fine tune products for specific market outlets.

21. Problems associated with the seasonality of production and variations in the weather are not insignificant. However, in the developed world, the food industry has established supply chains and processes which ensure that there is never any shortage of processed foods such as sugar, margarine and flour—all produced from crops. The paper industry already uses millions of tonnes of plant material—mostly from trees, but with a significant proportion from cereal and other straws. There is no reason to believe that such consistency and reliability could not be achieved in the production of industrial raw materials for non-food uses.

What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?

22. Plants are a sustainable, non-toxic and CO_2-neutral source of raw materials. The introduction of new species capable of producing specific and special products will add to biodiversity. Many opportunities for the use of plant-derived materials will be realised without the need for genetic modification but, properly managed and regulated, there is no reason why the use of GMO's to produce industrial feedstocks should pose any threat to the environment. In fact, the increased productivity and reliability these could bring to agriculture (in addition to more precise functionality), would reduce the area that needs to be cultivated releasing land for non-agricultural use.

23. Life-Cycle Assessment and Cost Benefit Analysis are two analytical tools that will need to be employed to ascertain whether sourcing materials from plants is the least environmentally damaging route to follow. The environmental impact of crop production (machinery, agrochemicals and fertilisers) together with the "downstream" processing techniques employed need to be taken fully into account. To take one example, in order to demonstrate more fully the environmental benefits that could be obtained from the increased use of vegetable oils as lubricants, universally accepted protocols for Life-Cycle Assessment need to be developed. SETAC (Society for Environmental Toxicology and Chemistry) is beginning to develop such protocols.

Are there regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?

24. Because of their benign nature, crop-derived materials could well be of assistance in helping industry to comply with increasingly stringent health and environmental regulations. For example, the need to reduce emissions of volatile organic compounds in the printing and paint industries could be helped by a move to water-based formulations using vegetable oils. The use of biodegradable vegetable oils as chain bar lubricants in forestry could reduce environmental damage (there is no legislation for this in United Kingdom but in Germany and Scandinavia the use of such lubricants is obligatory). The use of natural fibres or biodegradable plastics (based on starch) in packaging materials would help meet targets for the recycling and recovery of these materials.

25. There is a danger that the regulations concerning the commercialisation of GMOs may prove a considerable barrier to the introduction of crops based on this clean technology.

26. The EINECS (European Inventory of Existing Commercial Chemical Substances) regulations have already prevented the introduction of a number of crop-derived products in the United Kingdom. Under European law, any new chemical (even of vegetable origin) introduced into the supply chain needs to be registered. Each individual product manufactured in quantities in excess of 10kg needs to obtain EINECS registration. This is expensive, between £100,000 and £150,000 per product, and represents a considerable barrier to the wider use of crop-derived raw materials in the chemical industry. There are also anomalies, in that soya bean and linseed oil and their derivatives, eg epoxidised oils, have "generic" registration, whereas rapeseed oil does not.

In the light of the above, (a) are the current United Kingdom and European Union subsidies for non-food crops, and the proposals under Agenda 2000, appropriate; (b) are the local, national and European Union regulatory regimes appropriate; and (c) is the level and direction of United Kingdom and European Union public funding for research and development appropriate?

27. Under Agenda 2000 support for the production of non-food crops is dependent solely on area payments made under set-aside. This was a measure introduced in the 90s to regulate the production of cereals, oilseeds and proteins, thereby keeping food surpluses at a more acceptable level and reducing European Union expenditure on restitution payments to subsidise exports. The argument is that if food and non-food crops are treated equally, then the farmer can decide which to grow. However, this method of

regulating raw material supplies makes industry extremely nervous about placing any reliance on crop-derived raw materials which they already regard as unreliable because of their perceived weather dependence and seasonal nature.

28. The fact that, under this arrangement, farmers have a choice between receiving the area payment alone or the area payment plus any margin made from growing non-food crops has provided a source of relatively cheap raw materials for industry. However, although compulsory set-aside is theoretically now set at 10 per cent for the next six years, this rate could be varied at a moment's notice. In addition, the area payments are only available to crops on the European Union list of "supported" crops (as set out in Appendix 1 of the Intervention Board booklet: IM(C)41). This includes wheat, oilseed rape (and its genetically modified variants), barley and oats, but does not include most of the novel crops such as borage, calendula, woad etc. These novel crops are, therefore, at a commercial disadvantage.

29. If compulsory set-aside were put at 0 per cent, there is still the possibility of growing non-food crops on "voluntary set-aside". However, this means that, unless manufacturing industry is prepared to match the prices paid by the food industry (prices of rapeseed oil grown for industrial uses are currently about 20 per cent less than those for food outlets), farmers, who would no longer be obliged to set-aside any of their Cereals, Oilseeds and Proteins (COP) area, are highly unlikely to be prepared to grow such crops for industrial use.

30. What is required is a separate regime for non-food crops. Ideally, this should recognise three elements: energy (for which United Kingdom is currently evolving a system of support payments), fibres (for which the current regime provides generous, albeit reducing levels of support) and materials (the vast array of chemicals, polymers and biologicially active molecules for which there is no specific support). This scheme should allow non-food crops to compete with mainstream, supported crops, provide a level of support—to industry and agriculture—which reflects the range of environmental and social benefits associated with non-food crop production, encourage a focused and co-ordinated approach between different departments within the European Commission and encourage investment and growth, enhancing the competitive strength of the European Union in renewable production, research, technology and application.

31. In the United Kingdom, there is a good level of support for fundamental research, some of which will be of benefit in the development of non-food crops, eg United Kingdom scientists are among the leaders in understanding the metabolic pathways involved in plant lipid synthesis. However, the level of funding for strategic research is minimal. The current LINK Programme "Competitive Industrial Materials from Non-Food Crops" has a budget of £4 million over five years. Compare this with the annual budget of DM50 million for FNR (Fachagentur Nachwachsende Rohstoffe), the German "equivalent" of ACTIN.

32. There is also a need for the funding of "demonstration" projects which would help reassure industry that the inevitable problems associated with "scale-up" can be overcome. European Union funding for such projects is likely to be available under Framework V but it is worth noting the investment that has already been made in the United States of America under AARC (Alternative Agricultural Research and Commercialisation Corporation). This is a wholly owned corporation of the United States Department of Agriculture and receives an annual appropriation from Congress. It acts as a venture capital firm to help commercialise non-food agriculture products. In its first five years of operation it has invested $33 million in Federal funds and leveraged $105 million in private funds in setting up 70 projects in 33 States.

33. However, reference to this initiative should not imply that the sole responsibility for the development of non-food crops should rest with the Ministry of Agriculture. The importance of these materials for United Kingdom (and world) industry must be recognised by DTI and the benefits their production and use could bring to the environment should be acknowledged by DETR.

Ian D G Bartle
ACTIN Chief Executive

17 May 1999

APPENDIX 1

PRODUCTION OF CROP DERIVED RAW MATERIALS FOR INDUSTRIAL USE—MILLION TONNES

	UK	*Europe*	*USA*	*Global*
Vegetable Oils	0.07	2.6	3.0	12.5
Starch	0.25	2.4	6.5	15.0
Non-Wood Fibres	0.04	0.5	3.0	23.4
Total	0.36	5.5	12.5	50.9

1998 Figures.

APPENDIX 2

ANTICIPATED GROWTH: PRODUCTION OF CROP DERIVED PRODUCTS: MILLION TONNES

	Global Output 98	*Global Output 2003*	*% Growth*
Vegetable Oils	12.5	19.8	58
Starch	15.0	22.5	50
Non-Wood Fibres	23.4	28.4	21
Total	50.9	70.7	38.9

Notes:

VEGETABLE OILS: Projection based on Forecast for European Union growth (*Source:* FEDIOL).

STARCH: Projection based on forecast European Union growth (*Source:* National Starch).

NON-WOOD FIBRES: Projection based in Pira global forecast for pulp and paper use combined with European Union figures for non-wood fibre production.

Memorandum by ADAS Consulting Ltd

Executive Summary

ADAS welcomes the opportunity to provide evidence to the House of Lords' Select Committee. This report identifies the effect that CAP reform may have on the different non-food crops grown in the United Kingdom. It identifies those which require more than subsidy at the farming end of the production chain, and equally those which require increased support in order to compensate for risks and environmental benefits. The report summarises the current status of the main non-food crop groups, and predicts possible uptake during the next five years. The relevance of Life-Cycle Analysis and other environmental audits is considered.

Agenda 2000 in its current form may stimulate uptake of some crops, for example industrial oats, which may become more competitive alternative break crops as support for oilseeds is reduced. Alternatively, the production of other commodities may be rendered uneconomic by the changes, for example industrial linseed. Most, however, will be relatively unaffected by the changes either because current production is limited by failure of the "market" at some other point, or because existing payments are not sufficient to offset other opportunity costs or compensate for the perceived level of risk in a venture.

In our analysis of the non-food crops market we distinguish two major forms of crop; commodity and niche artisan crops. Commodity crops consist of those food crops with non food uses and large volume/low value novel crops such as biomass and fibre species. We identify that many of the constraints to market development of these species comes not from agricultural production inadequacies but from technical limitations in the marketplace. Thus we advocate that support should be de-coupled from area payments and targeted where appropriate for each crop/product.

Niche crops are more likely to stand alone with no additional assistance apart from AAPS set-aside payments. However, entry into new markets in order to facilitate import substitution may require pump-priming for the processor. De-coupling payments for 10,000 hectares of niche cropping may allow strategic support for those enterprises in most need.

For both commodity and niche crops we identify current status and the main bottlenecks to increased uptake. Where appropriate, the opportunities from GM technology are discussed. Needs for R&D, technology transfer and market stimulation are identified.

Finally, de-coupling support may also allow the true environmental benefits of particular crops and end products to be recognised. For example, environmental benefits from substitution of an autumn sown crop for a spring sown crop; improved energy ratio; reduced environmental impact from inputs. We discuss how this might be achieved in practice, and identify further research needs to produce a unified audit approach.

Introduction

1.1 *General introduction*

1.1.1 This document has been prepared by ADAS specialists working in research and consultancy on non-food crops. Because ADAS is independent and active across all sectors, we provide an impartial view of the opportunities for non-food cropping across all sectors within the United Kingdom.

1.1.2 Since the Review document *Alternatives in Agriculture* (POST, 1995) was published there have been significant changes in the markets and technology for non-food crops. Some areas, for example hemp, have seen year on year increases in the area cropped. Others are receiving added incentives for production on the

back of increased environmentally led demand, for example energy crops. Some, for example industrial linseed, are now under severe pressure due to changes in Common Agricultural Policy.

1.1.3 Our review considers the current position for biomass crops (short rotation coppice and Miscanthus), fibre crops (hemp and flax), oils crops (oilseed rape and linseed), minor oil crops (evening primrose, borage, calendula, crambe, euphorbia), dye crops, starch and ethanol crops and industrial oats.

1.1.4 Consideration of the relevant merits and long-term potential of these is given against the background of the most recent draft of Agenda 2000 proposals. Strengths and weaknesses in the market are discussed, and measures needed to stimulate viable crops are proposed where necessary.

1.2 *ADAS*

ADAS is the leading consultancy and research organisation to the land-based industries, working throughout the United Kingdom with expanding business overseas. With over 1,300 staff, a turnover in excess of £54 million and 50 years of experience that spans all aspects of land use, ADAS provides independent, impartial advice to both Government and private sector companies. Privatised in 1997, ADAS now has a Divisional Structure; Agriculture, Environment, Research, Professional Business Services and Ventures.

ADAS Agriculture Division is involved in advising on the management of over one million hectares of arable crops, 500,000 dairy cows, 60 per cent of United Kingdom poultry production and horticultural crops worth over £500 million. ADAS is probably the United Kingdom's longest established environmental consultancy. Our expertise ranges from management of land, soil, water and air to building design, engineering and surveying, supported by the latest analytical services and modelling systems. ADAS has an extensive R&D resource, with nine research centres in England and Wales covering the major United Kingdom soil types and providing study sites with wide climatic variation. Our research covers all major crop and livestock systems, and ADAS has considerable activity in novel crops research. ADAS research is active across the entire production chain and considers aspects of productivity, sustainability, ecology and environmental impact of agricultural and land-based systems.

Methodology of ADAS response

1.3 The ADAS response below draws on our impartiality and experience working with a wide range of crops. The viability of crops and products for non-food markets and ADAS's specific response to the evidence requested, has been formulated in the following manner:

1. By scale of potential market and likely value of the commodity:

1.3.1 Are there any regulatory barriers to the development of non-food crops, or disincentives within the current system of taxation and subsidies?

And in light of this...

(a) Are the current United Kingdom and European Union subsidies for non-food crops and the proposals under Agenda 2000 appropriate?

(b) Are the local, national and European Union regulatory regimes appropriate?

(c) Is the level of direction of United Kingdom and European Union public funding for research and development appropriate?

2. By crop specific questions:

1.3.2 For individual crops/crop groupings:

(a) What is the potential for the development of the non-food crop sector in the United Kingdom?

(b) Which crops, if any, are likely to prove significant in terms of their economic activity or land use?

(c) What is their potential to replace other less renewable resources and to pay their way, over the long-term?

(d) Can problems of consistency and reliability of supply be overcome?

(e) What are the environmental and ecological implications of the development of non-food crops?

(f) Can the potential of these crops be enhanced by genetic modification of plants or plant viruses, or by advances in processing technologies or other methods?

(g) How far can Life-Cycle Analysis on non-food crops be carried out, for comparison with conventional non-renewable materials?

2. Subsidies, Policies and Agenda 2000 Implications

2.1 *The need for support*

The principles contained with the European Commission's Agenda 2000 proposals envisage continued financial support for the agricultural sector. However, there is a commitment to evolutionary change reflecting economic, social and environmental pressures. The main policy themes, post 2000, conceptualised into an "ideal" model European farm, would embrace the following points:

- — developing a competitive agriculture sector which can gradually face up to the world market, without being over-subisidised, since this is becoming less and less acceptable internationally;
- — production methods which are sound and environmentally friendly, able to supply quality products of the kind and standard the public requires or demands;
- — diverse forms of agriculture, rich in tradition, which are not just output-oriented but seek to maintain the visual amenity of our countryside's, as well as vibrant and active rural communities, generating and maintaining employment.

2.2 The joint reforms required by the Agenda 2000 proposals and those likely to arise from the next World Trade Organisation round, are likely to result in the direct support for commodity crops being reduced still further. It is now anticipated that the following changes to the arable sector will occur:

Cereal Intervention prices

2.3 reduced by 15 per cent in two stages from 119 euro/tonne to 101 euro/tonne from 2001–02 onwards.

Area Aid Payments

2.4 Compensatory payments to be increased in two stages from 54 euro/tonne to 63 euro/tonne from 2001 onwards. Payments per tonne will be converted into area payments using the regional cereal reference yields agreed in 1992. This equates to 371 euro per hectare for England.

Set-aside

2.5 Compulsory rate of 10 per cent until 2006 (original expectation was 0 per cent). Voluntary set-aside remains.

Protein crops

2.6 Aid set at 72.5 euro/tonne from 2000 onwards. Payments per tonne are converted into area payments using the 1992 regional yields. For England this equates to 427 euro per hectare.

Oilseeds

2.7 Payments will be reduced in three stages to align with the cereal payment of 63 euro per tonne from 2002 onwards.

2.8 Whilst current Agenda 2000 plans are much "watered-down" from original expectations, it is widely expected that futher CAP-reform rounds will take place, and that these will place emphasis on imposing environmental constraints on farming practices, along with a gradual reduction in direct production based support.

2.9 Non-food crops offer a clear opportunity for diversification into environmentally sustainable cropping and when artisan based, offer the scope for greater rural employment, visual amenity value and preserve an element of rural traditions. Whilst the continuation of set-aside will allow the production of some non-food crops, their uptake is currently restricted by technical and market deficiencies which will require remediation through government support if they are to be grown. There are good reasons to advocate this support and combined with increased diversification of species, non-food crops often offer the following environmental advantages:

2.10 *Reductions in agrochemical inputs*—for example, industrial linseed, flax and hemp are all grown with significantly lower levels of input than many food crops.

2.11 *Reduced environmental impact of products*—where the biological product is competing in the market place with synthetic/petrochemical derived alternatives, non-food crops obviously offer indirect environmental benefits. For example, hemp fibres can be used as direct replacements for fibre-glass; energy crops displace fossil fuel electricity production; calendula oil might be used as a substitute for organic solvents in oil-based paints. These environmental benefits are extremely difficult to quantify in financial terms, but their importance is likely to increase significantly in future.

2.12 *Increased biodiversity*—springsown non-food crops offer the opportunity to displace autumn sown cereals, and could be linked with a statutory requirement to leave over-winter stubbles in place until spring. This approach is already advocated under Arable Stewardship Schemes (MAFF Agri-environment programme), where the correct management of ground cover is increasing habitat value for birds and ground dwelling invertebrates.

2.13 *Import substitution*—non-food crops can be encouraged in order to substitute for currently imported products which are in deficit within the European Union (ie linseed oil), or in order to dominate the European market (ie industrial oats). Non-food crops offer enhanced rural employment, both in new processing plant and also during crop production—many are labour intensive.

2.14 However, against these positive reasons for growing and processing non-food crops, there are currently considerable risks associated with their production. These risks include unpredictable yield (novel oilseed crops, coppice), poorly developed markets (hemp, flax), high investment risks (coppice, miscanthus), limited agronomic understanding (calendula, nettles) and lack of processing capacity (industrial oats). Somehow, these risks must be offset, if the advantages of these species are to be realised. This is the role of continued support.

2.15 However, whilst AAPS set-aside payments will continue to provide support for cropping, it fails to recognise that the constraints for many non-food crops come not simply from the risk of production, but from technological constraints and bottlenecks at the processing end. Some form of market support is required which allows these to be overcome, and thus allow greater commercially viable cropping to take place.

2.16 Additionally, as mentioned above, many of these crops can be grown in a manner that allows improved conservation management. Support can be linked to certain agricultural practices, in order to maximise the benefit of cropping diversification.

2.17 Before considering the specific requirements of individual crops and sectors it is appropriate to consider the proposed new methods for supporting non-food crops. ADAS has identified that two support systems will be appropriate depending on whether the crop could be considered a commodity crop (ie large area needed, multiple processors across the country) or a niche artisan crop (ie small areas to be grown which are processed by one, or a few operators).

Commodity and Niche Cropping

Commodity non-food and energy crops

3.1 This grouping must differentiate between food crops with non-food applications and true non-food crops. Whilst the methodology of support proposed is essentially similar, there will be subtle differences required for each crop. This paper suggests that support payments for these sectors should be partially de-coupled from CAP. Resource from EAGGF Guarantee Funds should be diverted towards market development measures in order to stimulate exploitation of existing technology. In many cases technology exists, in some cases initial or immature markets exist, but are insufficient to enable other than small scale processing to develop. Hence, targeted non-food market development measures could usefully be used to support necessary technology transfer, market and processing development and crop production initiatives. Administration of these funds could be delivered by RDA's, combining specific MAFF, DTI and DETR objectives, thus recognising the regional significance of particular ventures. The initiative should be sufficiently well resourced to allow premium payments to growers to ameliorate the risk involved in growing crops for this market. For example, fibre hemp or industrial barley would not be suitable for alternative markets should they fail to meet the required non-food standard for quality. Some form of guaranteed funding is required to provide confidence to growers to participate in such markets.

3.2 Thus payments from this non-food market development would consist of the following simultaneous measures, whose relative magnitude would vary according to individual market sector requirements:

1. Support for market development; including technology transfer, market and processing and product development.
2. Support paid direct to the farmer, based upon a secured contract with a processor. The magnitude of support would be determined by:
   - — the risks;
   - — the environmental benefits; and
   - — production constraints.

3.3 *Risks*—generally, for commodity non-food crops, the risks of complete agronomic failure are low. However, production of unusable feed-stocks, either due to climate or agronomy, is a significant cause of uncertainty in many sectors. Production of a crop which is subsequently rejected on quality grounds by the processor is an impediment to growers venturing into non-food cropping ventures. The agronomy of newly introduced species is generally poorly understood by the farming community. In these instances, additional payments that are not directly related to crop production are justified in order to provide confidence to the grower. Risk of market failure may also be assessed from the viewpoint of the processor, such as with linseed, where the processor will be unable to offer a price to fully compensate for the reduction in Area Aid. The

United Kingdom's European dominance of industrial linseed oil production will be threatened if growers do not receive sufficient support.

3.4 *Environmental benefits*—both direct and indirect. Direct benefits include reduction in inputs (compared with standard arable cropping), reduced tillage, improvements in flora and fauna associated with the farming environment as a result of new crop; species diversity, aesthetic improvements. Indirect benefits reflect substitution of products in the market place, with improved "greener" versions, CO_2 amelioration and meeting the United Kingdom's Kyoto obligations. Key to identifying the relative environmental benefits of non-food commodity crops will be the standardisation of life-cycle analysis systems. Should environmental audits of crops consider relative wildlife values (for example see Spink & Britt, 1998) carbon or energy ratios or comparison of the magnitude of xenobiotics used during crop production or produced during manufacturing purposes.

3.5 *Production constraints*—these measures offer Government the opportunity to regulate production practices in order to maximise environmental benefits. For example, compensatory payments may be made if spring cropping is followed in order to maximise value to birds by providing over-wintering stubbles (Marshall, 1998).

Example cropping and impact of proposals

3.6 It is anticipated that the above mechanisms would assist crops such as Industrial Product Cereals, Industrial Linseed, fibre crops and biomass, example scenarios are outlined below.

3.7 *Industrial product cereals—oats.* Oat production in the United Kingdom has remained static in recent years although increases have been seen in specialist sectors (eg naked oats). Further increases are dependent on the development of new markets. Objective 5b funding has been awarded to one project (Oatec) which is aimed at attracting investment in a high technology processing plant for the Marches region. This project is attracting commercial interest, the aim being to fractionate and purify extracted materials from oats which have applications in cosmetics, skin care and pharmaceutical sectors. Comparisons with a pilot plant in Canada have been made and it is currently estimated that an additional requirement for 50,000 tonnes of oats would be created by development of an industrial processing capability in the United Kingdom. The quality of oats required by the proposed plant would be quite different from that of existing markets, requiring varieties with high oil content and high β-glucan attributes. This will necessitate different crop management programmes to those adopted at present. The oats would be produced under a low input regime, offering both agronomic and environmental benefits. Support for the development of integrated agricultural/industrial projects, such as for industrial oats, can be justified and must be maintained if benefits in terms of rural down stream agri-industrial employment are to be realised.

3.8 *Industrial linseed*—ADAS budget planning exercises suggest that linseed margins will significantly decline if current Agenda 2000 proposals are adopted. The industrial linseed area will fall to a minimal hectarage. As linseed is more suited as a northern, rather than southern European crop, the United Kingdom has a competitive advantage. Support to this sector over several years has led to United Kingdom production dominating European Union grown supplies and add on activity in the United Kingdom crushing and refining sectors. Access to United Kingdom supplied linseed underpins this activity. This competitive advantage will be lost if the United Kingdom must rely on imported raw oil or trans-shipped seed for crushing. Sector support has given refiners the confidence to expand markets for United Kingdom linseed oil, adding downstream value. Traditional uses in paints, varnishes and linoleum and for oiling cricket bats! have been supplemented by new markets in agrochemicals, printing inks, textiles, paper manufacture and leather dressing industries.

3.9 *Fibres; hemp and flax*—hemp and flax production are currently supported by large area payments for non set-aside production and these are dependent upon contracts between the grower and processor. Both crops have very high potential for product supply into a range of market sectors. Current support reflects the risk associated with crop production, the relatively low price paid per tonne of retted product, complexities in harvest and post-harvest management and the imprecision associated with agronomy and final yield and quality. In addition, hemp support needs to consider the costs of adherence to Home Office production controls. It is difficult to envisage how either crop could be grown if the rate of centralised payment was further reduced, without a concomitant increase in price per tonne. The major constraint to exploitation (and consequently crop value) of these crops is expansion and development of markets. Whilst Government supported monopoly situations, such as occurs with hemp, may be justified during the early stages of crop development, market diversification needs to be considered. Competition between processors should result in more appropriate prices being paid to growers, and will enable regional enterprises to specialise in certain product lines. However, this will require co-operation between the Home Office and MAFF and relaxation of current production regulations. Hemp and flax can be seen to offer viable import substitutes for sisal and jute, and are low or nil-input spring-sown crops which offer many environmental advantages. Their continued support therefore merits high priority.

3.10 *Biomass*—perennial biomass crops, principally coppice but also miscanthus, require additional measures to ensure that long term raw material supplies are secure. Without this, such crops will fail. Although some additional measures are currently in place, the risks associated with commiting land to

perennial crops for 15 years (reducing the land's effective value by 80 per cent) are insufficient to stimulate the necessary grower interest. Biomass crops will be necessary, covering relatively large areas, in order for the United Kingdom Government to fulfil its Kyoto targets. The constraints of NFFO structures mean that biomass purchasers will be unable to pay the true value of their biomass. Additional direct support payments are necessary to (a) offset high start-up costs, (b) reflect the true environmental benefit of these species, (c) acknowledge that growing perennial crops reduces the growers options for subsequent opportunities and (d) compensate for the lower yields achieved by early adopters who will be unable to benefit from new significantly higher yielding clones predicted to become available within three years. These payments may take a number of forms:

— the high start up costs should be covered by a first year establishment grant (as is currently the case with project ARBRE);

— the environmental and social benefits of biomass cropping should allow the farmer to offset these against any carbon, fertiliser or pesticide taxes; and

— the long term nature of the cropping could be reflected by tax reduction on sales, or direct contributions where the growers, who would otherwise leave farming, choose to take the receipts as part of their pension. In some areas of the community this approach to support may help to maintain populations in rural areas.

3.11 *GMO's; non-food and energy*—many GMO technologies are targeted at food crops, but there are potential applications in the biomass and non-food crop sectors. These could include genetic modification of biomass crops such as miscanthus or the development of crops with high/modified starch contents for industrial alcohol production. The use of miscanthus for phytoremediation of land contaminated with heavy metals is being investigated (Kilpatrick et al, 1995) GMO technology is being applied to develop breeding lines expressing proteins with a high affinity to heavy metals. Over the 15–20 year crop life of miscanthus significant remediation could take place. However, stimulating the development of such technologies would rely upon a market for any biomass produced, "environmental credits" for its adoption or legislation requiring land remediation. Nevertheless, such scenarios demonstrate that GMO technologies can have a role in the non-food crop sector.

Niche crops

4.1 For the major market sectors identified in the introduction, many niche crops can be identified where markets for small scale artisan production exist. These markets offer high returns per unit of yield, yet yields are low or very unpredictable due to the novel nature of the species.

4.2 Examples of this cropping include essential oils, medicinal herbs, specfic fatty acid (SFA) oils, speciality fibres. Often with a single United Kingdom processor, these crops may be demanded on a strictly regional basis.

4.3 For these crops, where market and processing are understood but profitable production of the crop is the major contstraint, existing set aside payments may be sufficient to generate the farmer interest necessary for viable market production. However, if set-aside were to be phased out (as expected in early drafts of Agenda 2000 proposed CAP reform), the European Commission should grant the United Kingdom a derogation to support niche crops at varying levels on say, 10,000 ha of set-aside land over a 10-year period.

4.4 As with the present industrial crop production on set-aside, payments would be made to growers strictly on the basis that they are in receipt of production contracts with processors, and these payments would reflect the risk of producing crops with inherent sustainability and environmental benefits. These payments should be made available on a regional basis, targeted towards those crops and markets which can demonstrate sustainability and environmental criteria.

4.5 *Essential oil/medicinal herbs*—this is a priority area because the supply of health products of known quality and traceability from United Kingdom growers will underpin both growing and pharmaceutical/licensed health product companies in the United Kingdom. These markets are valued at £800 million. ADAS work has identified that the major constraints to larger scale adoption of these crops are technology transfer failures and market fragmentation (Runham, 1996). Technology transfer failure is in linking precise quality with traceability for international marketing, and in primary dissemination of agronomic knowledge.

4.6 *Specific fatty acids*—priority area with the potential to supply renewable quality oils into new markets. Development of novel oilseed crops will require sustained commitment over the long-term due to the long-term nature of plant breeding for example. Whilst product quality often matches supplies from non-renewables, consistency and confidence of supply, as well as price, is an issue for end users regardless of "environmental" cost. Pump priming developments via small scale projects are required to initiate such developments and related activities in research, oilseed processing and marketing. Pilot project can act as a basis for larger scale, lower risk ventures. Novel oilseed such as Calendula, Honesty and Crambe could fall into these categories.

4.7 *Organic farming*—the continuation of support for organic conversion will assist the oil, herb and pharmacuetical markets as there is an increasing demand for organically produced medicinal crops.

4.8 *Colourants from plant sources*—a recent MAFF funded review carried out by ADAS concluded that there was greatest potential for United Kingdom grown natural dyes and pigments in the food and drink rather than non-food (textile) sector. The risk involved in developing these niche markets was also acknowledged. Any developments would require strong industrial support providing access to markets and end-users, linked with resourcing to underpin research activities. Measures to pump-prime initiatives in the colourants sector are therefore similar to many other niche crops. Whilst colourants should not be excluded from future niche cropping proposals, they are likely to be a lower priority alternative crop in the United Kingdom.

4.9 *Additional financial support*—support for setting up new developments (like Objective 5b) would be needed, but should not be required in an on-going basis for this sector. Support required for R&D is needed to underpin activities in this sector.

Individual Consideration of Non-Food Species—Major Factors Influencing Their Current Market Placement

5.1 *Flax*

5.1.1 Flax production has grown rapidly during the mid 1990's, but the area has now started to decline. Whilst flax fibre from "pulled" types is of a superior quality to fibre derived from any other United Kingdom crop grown for apparel markets, most United Kingdom flax has been destined for paper production. Although high subsidies will continue to attract growers to the crop it is unlikely that the acreage will increase markedly in the next five years unless significant imrovements in yield reliability and weed control are seen.

5.1.2 The market for flax fibre is currently small, but has great potential to grow. The seed from flax is sold into the linseed oil market, but at present, the fibre from linseed grown for oil is not used. Linseed straw fibre is of lower quality than fibre flax, but has potential uses in MDF board and in industrial textiles. An expansion of these "dual purpose" linseed types would increase the marketing value of the linseed crop. However, dual purpose combinable flax varieties (for seed and fibre production) cannot be considered at present due to the fact that only named true-flax cultivars (in the United Kingdom Laura and Viking) are listed by the European Union as eligible for flax area payments. For any flax crops cut by combine harvester (rather than "pulled") there will be some linseed seed production which will go into the pool of linseed grown specifically for oilseed crushing (winter and spring-sown types), and the grower should be able to provide a seed yield estimate for this.

5.1.3 Nevertheless, dual purpose linseed may offer a way of mitigating Agenda 2000 effects. Production systems for dual purpose varieties which meet the contrasting requirements of fibre and seed markets have not been defined. There would appear to be opportunities to apply knowledge on linseed physiology to address this question. The balance between fibre yield, maximised by high seed rates and tiller populations and seed yield, which appears to be more closely related to capsule number, may be achieveable within one management system.

5.2 *Industrial oats*

5.2.1 There is considerable potential for development of the oat crop in the United Kingdom. The main limiting factor is the development of the new markets. Some efforts are currently underway in this area (Oatec—HGCA funded research). The agronomy package for oats destined for non-food uses is likely to be similar to that for feed types. The likely scale of production is 10,000 ha based on current estimates.

5.2.2 Due to a greater resistance to common cereal diseases than wheat or barley, oats require fewer fungicide sprays, leading to higher biodiversity in the farm environment. N fertiliser inputs are also lower than those for wheat and barley.

5.2.3 Oats are an excellent break crop in the cereal rotation but could not previously compete in this respect with oilseeds, due to the high level of subsidies for the latter crop. However with Agenda 2000 rates will be the same within three years at 118/acre. There are no regulatory barriers to the expansion of the oat area in the United Kingdom but public distrust of genetically modified cereals may limit the potential in this area. Closer regulation of the marketing of GMO's is likely to be a further disincentive.

5.2.4 Due to the limited area currently sown and the regional nature of the crop (at European Union level) it is more difficult to attract significant financial support. Obtaining funds for research on the oat crop is very difficult. Proposals for funding from HGCA are frequently seen as of much lesser importance that those on wheat or barley. MAFF also see oats as of lower importance than other cereals. The situation is different in the European Union—since oats are grown widely in Scandinavian countries they are seen as important in a European political context.

Industrial oils and Specific Fatty Acids

5.3 Some examples of these are given, rather than an exhaustive list of niche crops and products in this sector.

Evening primrose

5.3.1 Grown for the production of gamma linoleic acid (GLA) which is used in the medicinal and health food markets. The crop is grown under contract and United Kingdom production is approximately 1,000 ha. Contract prices vary, but are typically around £1,800–2,000 tonne. Yields are variable, ranging from 0 to 0.75 t/ha. It is not anticipated that the area of evening primrose will increase substantially in the foreseeable future. Evening primrose is grown in other countries and purchasers prefer to rely on a diversity of suppliers to ensure continuity of supply.

The crop can be grown as annual or biennial crop. Technical barriers include uneven ripening and poor pod set. Harvesting can be difficult. The major requirement here may be further strategic R&D to overcome technical deficiencies rather than any fiscal stimulation of the crop.

Borage

5.3.2 Borage, like evening primrose, is grown for its oil which has a high gamma linolenic acid content. Estimates suggest around 800 ha is grown in the United Kingdom, predominantly in Suffolk, Essex and Yorkshire. Demand slumped in the mid 1980s owing to over production in other countries. The area sown is limited by market size and is not expected to increase significantly. Prices are approximately £2,200 tonne and yields range from zero to 0.6 t/ha.

Agronomically borage has advantages compared to evening primrose, it is an annual, spring sown, has bigger seeds and faster earlier growth. However, seed shatter and harvesting are also problematic.

Calendula

5.3.3 Calendula or pot marigold *Calendula officinalis* should not be confused with marigold *Tagetes*. Calendula is currently grown for its essential oil, extracted from flowers by steam extraction, and used in cosmetics. This is a European wide, but relatively small market. There are imports of the essential oil from Eastern Europe and countries such as South Africa which has a favourable climate and low labour costs. However, current interest is in the seed oil, a C18:3 fatty acid, Calendic acid. The crop and its oil are currently being evaluated as part of a MAFF/European Commission funded research project (PL 97/3713). The oil has potential uses as a replacement for imported tung oil in paint formulations. The C18:3 fatty acid is highly reactive and such drying oils are important, particularly when solvent levels in paints are reduced. Currently 5,000 tonnes of tung oil are imported into the European Union, mainly from China and South America. The oil price varies widely, from $1,200 to $2,300 on world markets. Current requirements would indicated a potential crop area within the European Union of 10,000 ha. By 2004, small scale production on 500–1,000 ha should be possible if economic conditions are favourable.

There are agronomic and seed processing problems with calendula, but these can be overcome. Seed yields range from 1.5 to 3.0 t/ha and the seed contains 16–20 per cent oil. Seed shedding is a problem in the crop, but this is the subject of current research in the Netherlands. There are no pesticide approvals for calendula in the United Kingdom and no off-label approvals from other oilseed crops. This will significantly add to the cost of developing the crop in the United Kingdom.

Crambe

5.3.4 This crop is not currently grown in the United Kingdom or Europe, but has been the subject of previous and current European Commission funded research and appears to be expanding rapidly in the United States of America. Technical problems have been overcome, but it remains uncompetitive in Europe compared to other oilseeds as the market price is relatively low and the crop is not area aided.

Crambe would be grown in the United Kingdom for the same industrial oils as oilseed rape.

However, crambe production on a commercial scale would enable improved control of volunteer oilseed rape, and thus reduce contamination of say "00" oil crops from "HEAR" (High Erucic Acid Rape Seed) volunteers.

Euphorbia lagasacae

5.3.5 This species was screened as part of a MAFF/European Commission funded project investigating vegetable oils with specific fatty acids. The oil has some unique properties which suggest it might have uses in the lubricants sector. There are several technical problems to be overcome, including seed shattering and

irritant compounds in the seed. European Commission funding has been secured to investigate crop potential and opportunities for development of the crop in Europe, but such initiatives are likely to take 10 years before field scale production could be considered.

5.4 *Coppice/miscanthus biomass crops*

5.4.1 Short rotation coppice willow (*Salix*) and poplar (*Populus*) and miscanthus may be grown to provide ligno-cellulosic feedstock for biomass fuelled power stations. Since 1995 tremendous progress has been made towards large scale cropping with these species. Governmental targets now lie in the order of 125,000 hectares planted by 2010. This is in response to recently announced Govermental strategies for CO_2 abatement. The production of energy crops could become significant as the United Kingdom strives to produce 10 per cent of it's energy from renewables by 2010. It is conceivable that up to one million hectares of arable and grassland could be taken out of "mainstream" agricultural production by 2015 with the correct fiscal stimulants. Farmers may now plant coppice or miscanthus on 100 per cent of their IACS registered land.

5.4.2 ADAS has active research programmes in both coppice and Miscanthus, and these have been recently summarised (Bullard *et al*, 1997; MAFF 1998) and research priorities defined (Brent, 1998). Both have significant potential in the United Kingdom.

5.4.3 The hectarage needed to make a significant impact on energy consumption is large. A 30 MW power station (c 25 per cent efficiency) will require approximately 200,000 t of biomass annually. Assuming that this comes from crops with an annual yield of 12 t ha^{-1} (currently an average prediction for temperate Europe) then c 16,500 ha or 166 km^2 of land are needed. Optimistically, the actual cropping area, certainly in lowland Britain is unlikely to exceed 10 per cent of available land, therefore 1,660 km^2 is the minimum supply radius for the biomass to the power station (ie, a supply radius of 23km). This is significantly better that the 50 mile radius operated by project ARBRE. Transportation of feedstocks is a significant cost in energy cropping; the low energy density of biomass combined with transportation costs mean that a supply radius any larger renders energy generation uneconomic. This is in spite of efficiency gains in electricity generation which can be gained by moving from 30 to 100MW_e generation scale.

5.4.4 As generator efficiencies improve, with the movement towards gasification and pyrolysis systems for biomass conversion, it is likely that plant size can increase. One hundred MW_e biomass boilers already exist in the United States of America for use with forestry residues.

5.4.5 Energy (combined heat and power) generation from coppice is proven technology and coppice trees grow in the United Kingdom, albeit with relatively low annual yields. These are undoubtedly to be the main focus of energy cropping during the next five years, and an increase in area from, currently, $<1{,}000$ ha to 100,000 is likely. However, this expansion will only occur if driven by environmentally motivated fiscal support at both the conversion (through Non-Fossil Fuel Obligation) and primary production (grants to farmers) ends of the generation—production chain.

5.4.6 For coppice, although fundamental knowledge of the crop is available, productivity of crop, harvesting, storage and conversion efficiency can all be increased significantly if appropriate levels of research are funded. A structured breeding programme is in place in both Sweden and the United Kingdom which will provide valuable improvements in yield and harvestability during the next five years, although this will be reliant on a relatively narrow genetic base. The ecological benefits of coppice are perhaps overstated, although they are undoubtedly positive.

5.4.7 Miscanthus is still a development species, with no credible large scale commercial production in place in the United Kingdom. The life cycle is reasonably well understood, and some significant potential has been demonstrated on a small scale for both yield, husbandry and also suitability under conventional production systems. Like coppice, mscanthus would provide feedstock and require major harvesting operations at a suitable time in the year (March), thus spreading the labour workload on farm bringing financial benefits.

5.4.8 The lack of a nation-wide support mechanism is the single greatest impediment to uptake of miscanthus and coppice. As noted under section 3.10, there is a requirement of fiscal stimulation to encourage high risk perennial cropping and which provides financial acknowledgement of the environmental benefits of carbon neutral energy systems. However, a number of other constraints exist:

(a) the magnitude of feasible energy conversion systems is not consistent with centralised, national grid energy generation. This can be addressed through the stimulation of small scale embedded systems running at a local scale. This would simultaneously reduce transport requirements and CO_2 generation through transport fuel use;

(b) there is insufficient technology transfer of options for biomass energy generation, and the most advanced specialist crops (short rotation willow and coppice) have only recently entered breeding programmes specifically for increased biomass production. This needs to be expanded and take in other, potentially higher yielding species such as miscanthus and other perennial grasses. Equally significant advances in the agronomy of perennial systems should produce significant yield increases which in turn will improve the economics of biomass systems;

(c) work on reducing establishment costs and unit costs of production is equally essential;

(d) current work has focused on solid biomass energy generation. Liquid fuels from oilseed rape have been considered too expensive, with a poor energy ratio. Liquid fuels from either pyrolysis of solid biomass or gasohol/RME production should be considered afresh—high density liquid energy systems offer improvements in feedstock transport efficiency;

(e) many attempts to build biomass burning power stations have faltered at planning consent stage, often through misconceptions of environmental impact. Clearer Governmental guidelines on environmental impact (positive and negative) should be made available to planning authorities.

5.5 *Hemp*

5.5.1 Hemp has been cultivated for at least 6,000 years and was grown on most farms in the United Kingdom in the 16th Century. However, by the middle of the 19th Century the crop had virtually disappeared. Recent cultivation has been limited to a few European countries, notably France. The large scale development of cotton, jute and other tropical fibres and more recently the development of synthetic fibres caused the crop's decline. Prohibition due to the crop's narcotic content prevented cultivation for many years in a number of European countries. Interest in the crop in the United Kingdom has been stimulated by the relaxation of legal cultivation restrictions and the creation of processing facilities by Hemcore in 1993. Whilst hemp seed produces oils which have market value, currently United Kingdom production has focused on fibre only types. The stem contains outer fibre bundles of long (up to 20mm) bast fibres and a core containing short fibres (0.5mm). The bast fibre content depends on variety, plant population and growing period, and can range from 30 per cent to 45 per cent.

5.5.2 The United Kingdom hemp acreage has increased slowly during the last five years. A multitude of end uses have been demonstrated to be technically feasible by a number of European research projects, including MDF and other buiding materials, thermoplastics and geotextiles, and paper. However, there is no great pace towards commercialising exploitation of the crop in major markets other than for the waste (shiv) material in animal bedding, and some niche inclusion in internal car components. The potential for many hemp product markets is very large. The speed with which these markets can be exploited is reliant on the degree to which the cost of added value environmental benefits will be sustained by the consumer, and/or the degree to which greater emphasis on recyclability of components is supported by punitive taxation of non-renewable components.

5.5.3 Further commercialisation of the crop could undoubtedly occur were it not for the domination of one company in the United Kingdom scene. New companies searching to exploit niche markets (for example United Kingdom-based oil production) are hampered through their inability to gain access to seed supplies.

5.5.4 *Cannabis sativa* yield and quality will benefit from additional breeding aimed specifically at these traits. Unfortunately, too much emphasis to date has been placed in breeding for reduced content of psycho-active compounds (tetra hydro cannabinol), even though THC expression under United Kingdom conditions will never by high. Intense regulation of the production of this crop makes many farmers wary of committing to production. Product consistency and quality are currently poor, and result in many farmers growing the crop for one season only. Thus there is little continuity of experience and consequent improvement in growing techniques. Current field yields average less than five tonnes per hectacre, and current processing systems require a degree of field retting (2-6 weeks) in order to enable ease of fibre separation in the decortication plant. Recent research in a project led by ADAS (Hemp For Europe—Manufacturing & Production Systems. FAIR PL96 0396) has indicated that field retting actually diminishes the quality of fibre for certain applications (eg MDF production). The introduction of non-field retting systems would dramatically simplify production and improve the reliability of end product quality, plus reduce harvest losses significantly.

5.5.5 European Commission regulations require that hemp crops must have achieved seed set before harvesting can take place. Because of the relatively short growing season in the United Kingdom, and because hemp flowering is triggered by declining day length, this means in effect

(a) early maturing varieties must be grown in United Kingdom to enable harvest before autumnal climatic conditions hinder harvest

(b) in turn, growing early varieties limits the fibre productivity under United Kingdom conditions (fibre accumulation ceases onces flowering begins)

(c) Thus relaxation of these European Commission regulations would allow later, more productive varities to be grown. It would also open up the opportunity for growing stem and seed hemp varieties, and diversify markets.

5.5.6 The minimal inputs required of hemp mean that it is relatively environmentally benign, although from an ecological view the crop presents no particular interest. The deep rooting and smothering nature of the crop is claimed to aid soil structure and reduce weed burdens. The root system, stubble and a high proportion of the crop leaf is left in situ, ensuring an increase in soil organic matter and some nutrient return for the following crop. The crop should be considered as a satisfactory break crop from cereals but its *Sclerotinia* susceptibility could prove a risk to other break crops.

5.6 *Oilseed Rapes*

Double low (00) varities:

5.6.1 Originally and still grown for food, these cultivars contain low levels (typically less than 1 per cent) of erucic acid (which causes digestive upset in humans), and low levels of glucosinolates (a bitter sulphur compound which makes the meal by-product unpalatable and goitrogenic for animals). Current use of '00' varities include oil for human consumption, and high protein meal for animal feed. Industrial uses including feedstocks for pharmaceuticals and hydraulic oils.

High erucic acid rape (HEAR) varieties:

5.6.2 Grown specifically for their erucic acid content—typically 50–60 per cent of oil. Oil from HEAR varieties provides erucamide, a "slip agent" used in polythene manufacture, with a smaller proportion used to produce behenyl alcohol, which is added to a waxy crude mineral oil to improve its flow. Currently about 12,500 hectares of HEAR rape is grown on set-aside. The total rape area in 1998 was 533,000 hectares, 25,000 of which were on set-aside. 70,000 tonnes of seed were harvested from this set-aside. The value of the crop to the United Kingdom between 1984 and 1987 was estimated to be £217 million per year. By 1996 this had risen to £419 million.

5.6.3 While it is generally accepted that the level of oilseed rape production may fall after the reform of the Common Agriculture Policy, there is still a degree of uncertainty. Not least because the role of the production limiting Bair House agreement on oilseed support payment penalties has to be renegotiated in the next round of world trade talks starting in autumn 1999.

5.6.4 The role of both double low and HEAR oilseed rapes is relatively secure. There is an established market, and the oils are produced in sufficient tonnage's globally to be classed as commodities. Recent developments in the plant breeding, particulary hybrids has resulted in average annual yield improvements of about 3 per cent per year (compared to 1 per cent in wheat). Additionally they are relatively amenable to genetic manipulation which should maintain the speed of breeding improvements for both yield as well as opportunities to develop lines producing different oil types which should open up new markets. Another point is the market—crops have two major markets; oil and cake for the animal feed market. This provides greater stability in the market place.

5.6.5 Possible markets for existing and new oil types from oilseed rape have been summarised by Carruthers et al (1994).

Timescale	*Variety type*	*Industrial use*	*Market size (ha)*
Available now	Double low	Pharmaceuticals	30,000
	High-erucic/high-glucosinolate	Polythene slip agent	14,000 declining
	High-erucic/low-glucosinolate	Waxy crude-oil flow improver	2,000 increasing
	Double low/high-erucic	Hydraulic oils	Potentially large
Available within five years	High-lauric	Detergents, food	Potentially 40,000
	High-linoleic	Paints	48,000 (with high linolenic)
	High-linolenic	Paints	
Available after five years	Ultra-high erucic	Polymers, cosmetics, pharmaceuticals, inks	> 160,000
	High-ricinoleic	Lubricants, plasticisers, cosmetics	£100 million in France/United Kingdom

5.6.6 The main uses for 00 rape seed oil will continue to be cooking oils or margarines with the rape meal being used for animal feed. The double low varieties have almost no nutritionally undesirable long chain fatty acids, and can still be improved further by decreasing the linolenate content on average from about 10 per cent to 3 per cent, to give an enhanced shelf life. For industrial applications a very high content of oleic acid (80-90 per cent) is preferred, due to its suitability for certain chemical reactions and ease of extraction.

5.6.7 High Erucic Acid Rape seed (HEAR) has special properties, including high smoke and flash points, oiliness and stability at high temperatures, ability to remain fluid at relatively low temperatures and durability. Erucic acid is also used as a plasticiser in some plastics. Rape seed oil is currently incorporated into lubricants for two stroke petrol engines and rape seed oil—derived methyl esters can be used as a diesel substitute.

5.6.8 The energy ratios (energy produced:energy input) for the crop lifecycles are shown below.

Crop	*Energy ratio*
Double low (autumn sown)	4.46
Double low (spring sown)	3.50
HEAR (autumn sown)	3.76
HEAR (spring sown)	3.50

The higher yields from the autumn sown crop are shown up in higher ratios. The energy value of the straw is not included in the above figures.

Technical barriers and research opportunities

5.6.9 Much of the future potential for these crops lies in their ability to provide bespoke industrial feedstocks. The demand for higher yields will increase particularly if very high value oils can be produced. Arguably the nutritional benefits of rapeseed oil and its high levels of mono-unsaturates have yet to be fully realised in market potential. Additional nutritional and quality traits will be introduced into the crop, and put new demands on the agronomy of the crop.

5.7 *Starch and ethanol*

5.7.1 Nearly 800,000 tonnes of starch and glucose are produced annually from cereals in the United Kingdom. Just over 80 per cent of the total is glucose, while the remainder is split 40:60 between wheat and maize starch. All the maize used for both starch and glucose production is imported. One major operator in the United Kingdom has recently switched to wheat as a raw material rather than maize, and a new wheat based "refinery" has recently started production in northern France. Overall in the United Kingdom, the equivalent of over 1.25 million tonnes of grain are used for starch and glucose production. Approximately a further 2.4 million tonnes of grain are used in the brewing and distilling industry. The figure for brewing and distilling use has been between two and 2.5 million tonnes for most of the 1990s. In view of the intense competition in world markets both for the production of malting grains and the production of starch, projections to 2004 seem likely to stay within these ranges.

5.7.2 In northern mainland Europe potatoes have long been used as a source of industrial starch and for fermentation into alcohol, and specifically bred high starch industrial potatoes are now grown. A recent development has been the production of a very high amylopectin GM potato, although indications are that at this stage the crop may not be commercialised.

5.7.3 As the United Kingdom imports potatoes, largley as processed material, it is unlikely that the domestic production will be eroded by growers switching to low value industrial potatoes for starch production. Transport costs, and the potential spoilage losses of wet tuber material compare poorly with the high dry matter, low dirt tare, easily stored cereals. Additionally, as lower prices result from political and trade reform, the attraction of using cereals increases. As widely traded commodity crops, users can get price protection for their raw material by the use of futures and options; with very large tonnages traded world-wide there is a degree of buffering against large and rapid price fluctuations.

5.7.4 Sugar beet and potatoes have a higher capital requirement for their production, and also higher variable costs. At present any unique chracteristics, like using potato starch for paper finishing, for use as a chemical feed stock, are outweighed by the additional costs to the farmer and the problems mentioned above.

5.7.5 If trade and agricultural reform move the cost infrastructure of United Kingdom farming to a position where it can profitably produce grain at world prices, small grain cereals will be used more widely for industrial processes. Indeed, import sustitution would become an historic concept as grain would move freely in and out of the country governed by supply and demand. The use of novel starch crops like Jerusalem artichokes and Quinoa will be only of value to small scale niche starch users. It is difficult, in the foreseeable future to see them competing agronomically with cereal crops.

5.7.6 Cereal starches are now being used to produce low phosphate detergents, plastics, non-caryotic sweeteners, and a feedstock for many other organic compounds. In addition to the starch, straw has a wide range of uses from paper manufacture to furfurol production. Although many of these straw users are of peripheral interest at present, future developments could make the whole crop fractionation of the cereal crop an economically viable business.

5.7.7 Current GMO developments in grain structures include improvements in cereal starch for conventional uses like baking and brewing, improved grain enzyme activity, and modified starch structures.

5.8 *Dyes*

5.8.1 The largest opportunity for dyes derived from plants is probably as food colourants.

Area of use	*Present use*	*Likely potential*
Food colourant	Significant	High
Ink	Very small	Some but limited
Textile dye	Small	Some but limited
Cosmetic	Small	Some in specialised uses
Pigment (paints, plastics, etc)	Very small	Very small

5.8.2 The total value for natural dyes and pigments in the United Kingdom is probably about £9–12 million (1991 prices) per year for all markets. Natural products are far exceeded in production and value in the United Kingdom by the synthetic dyes and pigments, and overall the United Kingdom is a net exporter of all colourant types. Annual output looks to be relatively stable. The United Kingdom imports more colouring matter and tanning extracts of vegetable origin than it exports. However, the products imported are of considerably lower unit value than those exported.

5.8.3 Dyes are part of the speciality chemicals sector. The main driver for research and development in this sector has been environmental protection, especially in the area of minimising toxicity from solvents and pigments based on heavy metals. The use of natural dyes would appear to be less hazardous but would be likely to bring their own problems of pollution by mordants, disposal of plant wastes, and so on.

5.8.4 The major United Kingdom market for plant-derived colourants is food and drink. The world food colour market is growing at about 10 per cent per year. The total world market for food colourants was estimated to be in the region of $320 million in 1987. About $120 million was for natural colours, consisting of $35 million for natural extracted colours, $35 million for synthetic (nature-identical) colours and $50 million for process derived colours. The market for ß-carotene was estimated at $50 to $100 million per year, most of which was produced synthetically. The selling price of synthetic ß-carotene is about half that of microalgal ß-carotene. Opinion on the future development of demand for food pigments is conflicting. Some predict that interest in natural colours would have waned by the mid-1990s because of the increasing acceptance of synthetic colours.

5.8.5 Estimated global production of textiles has been estimated at about 30,000,000 t, with an estimated growth rate of 3 per cent per year. The consumption of dyes to colour these textiles is an estimated 700,000 t, with a value of about £2.5 billion per year (1988 prices). Dyes represent < 1.0 per cent of total world sales of organic chemicals. Elsewhere, the global annual sales of dyestuffs was estimated at £7 billion in 1989, with prices for dyestuffs ranging between £20,000 and £50,000 per ton.

5.8.6 Within the European Union, the sales of dyes (all types) for textile dyeing have declined recently (Anon, 1994). About 9 per cent of manufacturing employment in the European Union is in the textiles and clothing industries (2.7 million people in 1992). Overall production is declining, as the gap between exports and imports widens. The European Union textile industry is relatively modernised with a high proportion of shuttle-less looms and still has a strong competitive position in technical textiles, eg, geotextiles. The critical factor for textile production is the price volatility of raw materials, including those based on petrochemicals. Natural dyes could reduce dependency on petrochemicals and help dampen the price volatility of the raw materials but their impact is unlikely to be great as they constitute a relatively small part of the current costs.

5.8.7 In Italy, the dyeing industry is interested in finding alternatives to synthetic dyes because of the high pollution load of modern textile dyeing processes. The use of textile products in 1996 was about 30 million t; the use of natural dyes was less than 1 per cent of total dye use.

5.8.8 In the United Kingdom woad is receiving most attention at the moment, in a project to develop an ink that can be used in inkjet printers, primarily for labelling. There is also interest in developing elderberries as a source of red food colouring, for which it is already used, which could lead to the development of plantations of *Sambucus* spp as has already happened in Germany and Denmark. Two textile dye plants, madder and weld, have also excited interest recently in the United Kingdom and the European Union. Any significant development is likely to come from these crops.

5.8.9 It is worth remembering that several dye substances are also active in other ways, eg, riboflavin, and that several dye crops are potentially multiuse crops, eg, nettles, elderberry. The extraction and use of a dye substance could be one reason—and not necessarily the most important one—for growing a particular plant species as a crop.

5.8.10 Plant-derived dyes used as textile dyes have very stiff competiton from synthetic dyestuffs, which are predominantly derived from petrochemicals and have many advantages over the "natural" product, eg, consistency of quality and supply, superior dye strength, price, colour fastness, ability to dye synthetic material, etc. There is a relatively small niche market for "natural" dyes for clothing and furnishing for the hobbyist and also a small proportion of consumers. The main "natural" dye sold is indigo (blue jeans) but that is currently supplied more cheaply and efficiently from *Indigofera* grown in India and Asia than from woad grown in Europe. Given the much better dye yield of indigo from *Indigofera* and the cheaper labour costs, plus fewer environmental financial costs, that are likely to continue operating for some time in India

and Asia, indigo from woad is unlikely to be competitive as a commodity. There may be a niche use in the United Kingdom, particularly where production is subsidised.

5.8.11 Plant-derived dyes used as food colourants have already supplanted artificial colourants in many foods, because of health concerns about some of the artificial dyes and because "natural" colourants tend to be preceived (rightly or wrongly) by the consumer as better than artificial ones. It is likely that this trend will continue and there will be more opportunities for growers to supply this market. However, this is not likely to be a volume commodity market but one of relatively high value and small volume. Plant dyes can be extracted during processing for other uses and from waste. In addition, for some commonly used dyes (eg, tumeric) the supplier is outside of the United Kingdom or European Union.

5.8.12 In general terms, although in theory there could be considerable substitution of artificial colourants by plant-derived colourants, it is unlikely to happen unless the financial balance is skewed towards plant dyes through subsidies or by taxes on the artificial colourants (or their precusors), or unless consumer opinion is sufficiently in favour to force the shift via market forces or through political or legal change. In the latter case, this is probably most likely to start in other European Union countries, such as Germany, where public opinion is already greener.

5.8.13 Consistency of quality could be improved by investment in making dye plant species into crop plants by breeding and agronomic research (unlikely to happen unless there is a proven market).

5.8.14 Traditionally most plant dyes have been used with very little extraction from the parent plant material. Such supply tends to be seasonal, with some opportunity to extend availability by drying, although this is not applicable to all plant dyes. Continuity of supply could be improved by developing extraction and storage techniques appropriate for each dye, possibly on-farm. For plant dyes, improving reliability probably means paying attention to quality, as above, and understanding how the colourant performs with different substrates and under various conditions, eg, **pH** changes in food during processing and cooking.

5.8.15 The environmental and ecological benefits include increased agricultural plant diversity, profitable farming maintaining rural infrastructure, landscape and community, opportunities for developing on-farm processing and non-farming enterprises on-farm. Better products for consumers. Costs include increased rural traffic (transport of plants/product from farm), problem of waste disposal (waste plant material, by-products of on-farm processing) and possible environmental pollution, reduction in United Kingdom-produced foods and increase in imports.

5.8.16 The ADAS prediction for increases in these market sectors is that food and drink could sustain 5–10 per cent increase per year, whereas other sectors will show no significant change in next 5–10 years (unless something happens to restrict supply of petrochemicals and/or there is a major shift in public opinion).

5.8.17 The major technical barrier is that there are few, if any, varieties or genotypes of dye plant species that have been developed for cultivation as commercial crops. Supporting crop husbandry information is also lacking. Harvesting/processing/extraction techniques have generally been developed for small-scale or craft use and would also need revision/development for industrial use.

6. *Environmental benefit assessment—the role of life-cycle analysis*

An appropriate mechanism for differentiating between crops or manufacturing processes, in the event that there is competing demand for resources, will be the environmental audit. ADAS have presented a comprehensive review of the relative environmental and economic benefits of growing non-food crops on set-aside, against a reference of natural regeneration[1]. These could be adapted to enable direct comparison of two cropping options. ADAS has also calculated energy ratios for these crops. These research findings are summarised below for key species. They will allow direct comparison with energy ratios for products produced from non-renewable or non-agricultural systems. However, even these do not consider the long term environmental benefits or disbenefits. For example, the high energy ratio of miscanthus fails to considered the long term benefits of CO_2 displacement (in terms of indirect economics) which further increase its enviromental credentials; the so called information of externalities. Work should be conducted on how these two systems can be integrated.

[1] Spink J & Britt C (1997). Crops for Set-Aside Land: An economic and environmental appraisal. MAFF project report.

Annex 1

COMPARATIVE ECONOMIC AND ENVIRONMENTAL RANKINGS OF FOOD AND NON-FOOD CROPS (AFTER SPINK & BRITT, 1997)

Crop	*Net margin (1–5)*	*Flora and Fauna (1–5)*	*Soil protection (1–5)*	*Pesticides in water (1–5)*	*Nitrates in water (1–5)*	*Total environmental (sum cols 2–5)*	*(sum cols 1–5)*	*Energy ratio*
Wheat	4	1	2	1	4	8	12	8.82
Barley	3	1	3	1	4	9	12	—
Industrial Oats	4	1	3	2	4	10	14	7.78
Winter HEAR	2	1	3	2	4	10	12	3.76
Spring HEAR	2	2	3	2	4	11	13	3.50
Winter oilseed rape	2	1	3	2	4	10	12	4.46
Spring oilseed rape	2	2	3	2	4	11	13	3.95
Linseed	1	2	2	3	4	11	12	4.52
Dual purpose linseed	3	2	2	3	4	1	14	5.72
Flax	4	2	2	3	4	11	15	11.96
Hemp	3	2	2	5	4	13	16	8.46
Winter evening primrose	4	1	3	1	4	9	13	3.70
Spring evening primrose	5	2	3	3	4	12	17	—
Borage	5	2	3	4	4	13	18	—
Sugar beet	1	1	1	2	4	8	9	—
Potatoes	2	1	1	2	3	7	9	—
Short rotation coppice	4	3	2	1	4	10	14	30.00
Miscanthus	5	2	4	3	5	14	19	32.53
Broad-leaved forestry	5	5	5	5	5	20	25	—
Conifer forest	4	4	3	5	5	17	21	—
Sown grass covers	2	3	3	5	5	18	20	—
Natural regeneration	**3**	**3**	**5**	**3**	**3**	**12**	**15**	**—**

Key indicators compared with natural regeneration scored on a 1 to 5 scale, where 1 is significantly worse, 3 equal and 5 significantly better than natural regeneration.

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5 May 1999

Memorandum by ARBRE Energy Limited

1. *What is the potential for the development of non-food crops in the United Kingdom? Which crops, if any, are likely to prove significant in terms of economic activity or land use?*

Currently renewable energy contributes around 2 per cent of the United Kingdom's electricity supply. The European Commission in its Council Resolution of May 1998 identified the potential to double Europe's energy supplies from renewables (currently around 6 per cent) by 2010 as a major contribution to reducing greenhouse gases to comply with its Kyoto obligations. Biomass is predicted to supply around 50 per cent of the 2010 target, equivalent to an installed capacity of 10,000 MW.

Our experience relates to the growing of short rotation coppice (SRC) as part of the wood fuel supply for our ARBRE project. Associated activities of sludge disposal, landfill site design and land reclamation can benefit from SRC as it produces an end product, but is not specifically covered in this evidence.

ARBRE will require 42,000 oven dry tonnes of wood per year and will export eight MW of electricity to the local grid. The United Kingdom is expected to call for 10 per cent of electricity supplies by 2010 of which 1,000 MW of electricity generation will come from biomass projects of which the majority will require fuel supplies from SRC. The precise amounts of SRC needed will depend upon generating plant energy conversion efficiency, SRC yields and their percentage contribution to wood fuel supplies. In the table below, a conversion efficiency of 40 per cent has been assumed, based on predictions for the ARBRE technology as it scales up. Other, less efficient technologies such as pyrolysis (c. 20 per cent) would require proportional increases in the fuel areas required.

Energy crop yield	*100% supply*	*75% supply*	*50% supply*
12 odt/ha/yr	230,000 ha	175,000 ha	116,000 ha
15 odt/ha/yr	186,000 ha	140,000 ha	93,000 ha

ADAS studies have shown the potential for growing energy crops in the United Kingdom is greater than one million ha. This indicates a substantial potential exists for SRC. Projects developed in other parts of Europe will require proportional amounts of wood fuel.

Long term employment will be created in the biomass sector; we estimate that some 7,000 full-time equivalent jobs will be created by the development of 1,000 MW of biomass projects. If the know-how can be exported this number will rise dramatically.

2. *What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg by genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability be overcome?*

The potential of energy crops has been evaluated by the DTI and the European Commission. Energy Paper 62: New and Renewable Energy: Future Prospects in the United Kingdom (March 1994) assessed the potential contribution that each of the renewable energy technologies could make to the United Kingdom. The three main resources are: offshore wind energy (380 TWh/year); onshore wind energy (340 TWh/year); and energy crops (190 TWh/year). The 1992 United Kingdom Electricity Supply was 310 TWh/year; the biomass accessible resource represents 64 per cent of that total. The European Commission's TERES study assessed the SRC potential resource in Europe as 820 TWh/year. The potential is directly related to the area planted and the yields achieved per hectare. It is a large potential. There are also possibilities for including a range of fuels within this technology, which will improve the economics for electricity generation, and help the market penetration for this sector.

In order for SRC to replace other less renewable energy resources a number of political, technical and financial actions are required. Most renewables are currently more expensive than fossil fuelled power stations due to their infancy, project size and market share. However, their costs have fallen in the United

Kingdom during successive rounds of the NFFO and they are becoming more competitive with the other technologies. Continuing this trend (and with more participants) will enable a faster penetration into the market and the ability to export. The actions needed are:

- continuing political will and support to implement renewable energy programmes, including fuel supplies from the agricultural sector. In particular this requires effective co-ordination between United Kingdom Government Ministries and the European Commission;
- the financial support received by farmers from the CAP should not discriminate against energy crops and should recognise their long term nature. This is especially important now at the early stage of their proposed use;
- technical development of energy crops. Fuel consistency and reliability are starting to be addressed via the existing willow plant breeding programme. It is producing crop yield increases, better form and disease resistance and has achieved significant improvements to date with further developments looking promising. It therefore needs to be continued. Parallel programmes for other promising energy crops such as miscanthus will bring crop variety and competition into the markets;
- this programme needs to be continued with willow and replicated with other new energy crops and include appropriate methods and techniques to improve plant yields and plant health. The potential for yield increase is substantial and needs to be pursued;
- an independent monitoring programme is needed to ensure experience is gained and results are transferred to the biomass sector;
- very little has been done in the United Kingdom to provide financial support for the design and manufacture of machinery and knowledge for SRC havesting, storage, fuel supply logistics and transport. This is a high priority area and is urgently needed;
- GM biomass crops have the potential for even greater improvement in yields and disease resistance. However, no information has been made available to date by plant breeders as to whether or not this is a viable option to pursue. There will also be the issue of demonstrating acceptability to the public at large. At this stage a full independent study should be undertaken, to ascertain the potential benefits and disbenefits of GM biomass, before attempts are made to implement this.

3. *What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?*

Research has been carried out by the DTI to assess the energy balance of wood fuel production from SRC, that is how many units of energy must be expended to produce each unit of energy contained in the wood chips. This has shown energy balances in excess of 1:20 (energy in: energy out) so SRC is clearly a net energy provider.

SRC is a robust crop—it can be grown on all grades of agricultural land and land that would not be suitable for conventional agriculture including land reclamation. There are many ex-industrial sites, old mining spoil heaps that are currently desolate. With the application of digested sewage sludges to improve the nutrient status, SRC can be grown successfully, and over time it will serve to improve the soil and regenerate the land. SRC is an efficient way of removing excess nutrients in soils, thereby reducing leaching into watercourses.

ARBRE has utilised the national SRC Guidelines to demonstrate how sensitive planting design can achieve good visual effects. On water uptake, the water use of SRC is higher than that of the main agricultural crops and broad-leaved trees but less than that for pine forests. A study by Hall et al (Ref ETSU B/W5/00275/REP) recorded transpiration rates of 350-390 mm per annum for broad-leaved trees (ash and beech forests) and 500 mm per annum for SRC. Initial studies on grassland show that grass has a transpiration rate higher than broad-leaved forests but probably not as high as SRC.

In comparison to an arable row crop, SRC production requires far lower input of pesticides and other agrochemicals and fewer machinery passes; it therefore represents a lower impact form of agriculture. It will also add to the ecological diversity of the agricultural landscape. In particular, the coppices themselves provide nesting and foraging habitats for birds and support many insect species. Coppice design incorporates headlands and rides that provide the open and edge habitats favoured by different communities of plants and animals. Songbirds occur in high numbers in SRCs; in particular migratory species such as warblers are found in greater numbers in second and third year coppice than in other woodland types, including traditional coppice. SRC provides abundant invertebrate food for foraging birds and mammals and habitat for species nesting low in the crop. The crop is harvested every three years etc etc.

4. *Are there regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?*

Barriers/disincentives do exist to the development of SRC. Please see 5 below.

5. In the light of the above, (a) are the current United Kingdom and European Union subsidies for non-food crops, and the proposals under Agenda 2000, appropriate; (b) are the local, national and European Union regulatory regimes appropriate; and (c) is the level and direction of United Kingdom and European Union public funding for research and development appropriate?

(a) NFFO as one support system for electricity production provides an end use for the product, but the emerging market players in SRC need help to provide cost-effective incentives to the agricultural part of the industry. The subsidies for non-food crops have enabled SRC growers to come forward for ARBRE. We have planted 200 ha and a further 300 ha in 1999. This will supply less than 20 per cent of the fuel supply for the ARBRE project. The uptake has been far too slow and part of the reason for this has been the uncertainties in the subsidy regimes. These relate to the following points:

- comparisons with food crop incomes have changed dramatically over the last four years. This has led to uncertainty in the minds of potential growers of SRC;
- there is no annual area support for SRC growers whose land is in grassland. This is a matter of serious concern and needs to be remedied;
- annual support for arable land is provided from set-aside and is guaranteed only for five years. We have contracts with growers to supply wood fuel from SRC for 15 years. The big question in growers' minds is what happens to area support after the five year period;
- set-aside is strongly disliked by most farmers, so there has been resistance to be associated with it. It brings uncertainties with annual changes in compulsory percentages and changes in aid. A percentage of the monies paid for set-aside should be targeted to the support for energy crops. Compulsory set-aside is understood to be set at 10 per cent until 2006;
- crops such as miscanthus currently do not qualify for planting grants. We understand that this is being investigated by MAFF as part of the Agenda 2000 settlement. It is important that grants are obtained for miscanthus, together with an annual payment structure.

In 1994 ARBRE held discussions with Inland Revenue and Treasury to ascertain whether SRC could benefit from tax exemption offered to Forestry. This was not accepted by the Revenue. It needs to be re-examined as a means of encouraging growers to enter the market, to provide a clear message of Government intent to the market place and as a means of reducing fuel prices.

The effect of the Marshall proposals and the recent Government initiative to use fiscal initiatives for the Climate Change response is not yet clear but undoubtedly could offer assistance to SRC.

Energy crops need a support system targeted and named as such. This has to be delivered by the United Kingdom Government and DG VI.

(b) The regulatory regime for energy crop support is currently administered through the Forestry Commission's Woodland Grant Scheme (WGS). Applications for establishment grants take 3 months to process, which is due to the need to place site details on public register, receive responses (if any) and process the paperwork. This is cumbersome, needs to be streamlined and possibly moved into the agricultural part of MAFF. The WGS also creates an unnecessary perception by potential growers that SRC is woodland, and has acted as a deterral.

(c) Research and development funding for SRC has been provided, mainly by the DTI. MAFF has provided assistance with seminars for potential growers. This function needs to be continued and developed into support for future projects fuelled from energy crops.

The wood fuel will require to be transported to the generation site at Eggborough. We believe it is important for Government to encourage the transportation sector to promote infrastructure initiatives to aid and facilitate the movement of biomass fuels. At present, the taxation of fuels is acting as a disincentive for the sector, as it hinders the start-up period for biomass fuelled power stations. Rail would be a great benefit if railways went into forests, and railheads could be established at the power stations, but major forests, such as Keilder where, perhaps half a million tonnes of timber could be extracted each year, have had their rail networks ripped out.

During the years that short rotation coppice is being developed, the two major sources of fuel offered by Forest Enterprise are from the forests of Kielder and East Anglia. Both are over 160 miles from the power station and the road transport round trip costs of the order of £360, of which between 25 per cent and 30 per cent goes to the Exchequer in fuel tax and vehicle excise tax.

In the case of the pioneering work that ARBRE Energy Limited and others are undertaking on behalf of the environment and the United Kingdom, it could be appropriate for vehicles employed totally in the movement of biomass for fuel should not only be virtually exempt of vehicle excise tax but that there should be a rebate of the tax on the diesel during the first five year's of a power station's working life. The tax benefits should only be seen as an "enabling" facility to create new supplies of fuel while the power stations are being built closer to the fuel sources.

13 April 1999

Memorandum by BABFO (the British Association for Bio Fuels and Oils)

Introduction

Liquid biofuels, biodiesel and bioethanol, are practical and immediately useable road transport fuels with far lower harmful emissions than are produced by normal fossil fuels. These advantages are well documented and the relevant information can be provided to the committee if your Lordships wish.

Essentially, no extra CO_2 is put into the atmosphere on combustion as the carbon liberated will have been fixed the previous year when the relevant crop grew. Biodiesel and ethanol contain no sulphur and emissions are therefore sulphur free. Other emissions are on balance better than for fossil fuels especially if injection timing on the (diesel) engine is advanced 3–4 degrees. Biofuels degrades harmlessly in a short time if spilt unlike fossil diesel and oils, which can cause substantial environmental damage on a spillage.

This Association covers the Committee's five specific points as follows:

(1) Biodiesel would be produced in this country from oilseed rape. (OSR) None is produced at present as basic production costs are two or three times the (currently very low) price for fossil fuels. Bioethanol is often a by-product from wheat, potatoes and sugar beet processing though whole crop distillation of wheat is practical given the right financial relationships between cost of raw material and selling price inclusive of tax. There are rotational limits on the amount of such fuel crops that could be grown. In practice, in the short-term, an area of 250,000 ha of OSR grown for biodiesel would produce of the order of 300,000 tonnes of fuel per year on present levels of yield. (1997 United Kingdom OSR crop was 446,000 ha.) More than three times this tonnage of biodiesel could also be forthcoming as bioethanol, one third of which might be a by-product from existing extraction operations from cereals. It can be argued that some 3.5 million tonnes of wheat (out of a total United Kingdom production of say 16 million tonnes) could be available for bioethanol and would produce about one million tonnes of fuel. If whole crop distillation were carried out, harvesting the straw as well as the grain just prior to normal ripeness, an amount closer to 1.25 million tonnes could be anticipated. In round terms, 250,000–300,000 ha of OSR could produce .3 million tonnes of biodiesel per annum and 500,000 ha of wheat could produce one million tonnes of ethanol per annum, a total of say 1.3 million tonnes of liquid transport fuel of very high environmental quality and representing 8 per cent of the annual 17 million tonnes of DERV used. This implies up to 800,000 ha for liquid fuel production, 7 per cent of the United Kingdom farmed acreage of some 11.5 million ha—28 million acres. It also indicates a cut of 1.3 million tonnes in fossil diesel use equal to a drop in CO_2 emissions of approaching four millon tonnes as well as related reductions in sulphur and other harmful emissions.

(2) The ability or otherwise of OSR and starch crops to pay their way as raw materials for road fuels is at present entirely within the remit of the Chancellor of the Exchequer who sees fit to tax biodiesel at the same (crushingly high) rate as fossil fuels, 47.21p per litre for "ultra low sulphur diesel". This is nonsense of the first order as the high level of tax is imposed on (fossil) fuels specifically to try to curb their use to cut pollution. So why tax biofuels which do not pollute to anything like the same extent? Your Lordships strongest representations on this point may seem appropriate. Plant breeding techniques could be of real significance for bio oil production. If nitrogen-fixing bacteria can be transferred from clover plants to OSR (to reduce the need for nitrogenous fertiliser) and yields can be increased in the same way as has been done for wheat, then unit costs could be reduced making production more economic. The Max-Planck Institute (Cologne) is forecasting a doubling of oil yields from the current 1.4 tonnes per ha to 2.9 tonnes by 2020 from technical advances. At present, biodiesel costs perhaps two or three times the present very low (12–15p per litre) cost of fossil fuel but the International Energy Agency is forecasting world shortages and rising prices from 2010 which can only be met (in their language) by "unidentified unconventional sources." Thus, reducing costs of biofuel production, rising costs of fossil fuel and an intelligent tax policy could mean a steady increase in the amount of farmland used for liquid fuel production. (At the turn of the century, one fifth of the farmland of England was used to grow transport fuel crops—oats and hay for horse feed. We could, in the next century, again see 20 per cent of our farmland producing transport fuel, biodiesel and bioethanol).

(3) There are no particular environmental or ecological implications for growing starch-based crops for distillation or OSR for biodiesel. It has been put to us that the latter crop would be more popular with the general public if we changed the flower colour to a delicate shade of blue or pink but yellow is popular on the continent so what do we do? Considerable work has been done on the Life-Cycle Analysis for OSR for biodiesel and this is favourable (references can be provided). We are however concerned that comparisons with other fuels may not have been carried out fairly. For instance, the cost in energy and pollution costs of commissioning and decommissioning oil drilling rigs and the similar pollution and energy costs of all the pipe work under and above ground pipe work may not be included but the easy to measure agricultural costs of cultivation etc, may be fully included to the comparative detriments of biofuels.

(4) There is a massive and quite illogical tax disincentive in the United Kingdom against liquid biofuels (see section (1) above).

(5)(a) The Blair House agreement includes "soya equivalent" land even if it is producing oilseed rape for fuel rather than food competing with United States soya exports. This is nonsense and must be removed on logical grounds in European Union/United States negotiations/agreements. It would be sensible and helpful under Agenda 2000 (assuming that any valid agreement is reached) if specific amounts of Set Aside land were nominated for liquid fuel crops with an appropriate area payment so that the European Union target of 8 per cent of liquid transport fuels from renewable sources by 2010 could have a chance of being met. (b) The DTI and DETRA have not envinced much support for liquid Biofuels. This antipathy is based, we believe, on work carried out by AEA Technology plc (ETSU) at one time a Government agency. The work has been seriously flawed on grounds of methodology, assumptions and most seriously, interpretation. But getting Civil Servants to admit they might have been wrong is difficult. The writer has been told by an ETSU official that they knew the DTI did not like biodiesel and as "he who pays the piper plays the tune" they make sure DTI got what it wanted. (c) Some practical United Kingdom Government help for liquid biofuels (through grants or excise duty relief) akin to that given generously to wind power and short rotation coppice for electricity generation would seem to be in the national interest. The European Union takes a more positive line on Biofuels. There is an European Union White Paper on Renewable Energy Strategy which postulates 8 per cent of liquid transport fuel to be from renewable sources by 2010. In the United Kingdom, 8 per cent of the current DERV useage would be 1.35 million tonnes pa to be taken by a fossil diesel alternative. This is achievable on the basis of the figures in 1 above which demonstrate 1.3 million tonnes. There is also provision in European Union legislation for fuel tax relief for "Pilot Plants" producing up to 2 per cent of the relevant fuel. (Say 340,000 tonnes for the United Kingdom.) France, Germany, Austria and Italy make use of this aid to maintain a small but potentially useful biodiesel industry. Why not the United Kingdom?

Peter Clery
Chairman

Nicholas Tapp
Director

March 1999

Memorandum by BASF plc

We would comment as follows:

1. There is a large potential for the development of non-food crops in the United Kingdom. Such non-food crops would be non-fossil derived intermediates, energy and medicinal crops.
2. These crops could potentially replace other less renewable resources in the long term. This could probably be enhanced and problems of consistency and reliability be overcome.
3. The implications of the development of non-food crops are similar to the conventional ones.

4/5. We are unable to answer these questions.

31 March 1999

Memorandum by BBSRC (the Biotechnology and Biological Sciences Research Council)

Introduction

1. The Biotechnology and Biological Sciences Research Council (BBSRC) was established by Royal Charter in April 1994. It is a non-Departmental public body principally funded by the Department of Trade and Industry via the office of Science and Technology and through the Science Budget. BBSRC-sponsored Institutes receive a proportion of their funding from the Ministry of Agriculture, Fisheries and Food (MAFF), by means of research commissioned on a consumer/contractor basis, and research support from other Government Departments, the European Union and industry.

2. The Council's mission is:

— to promote and support high quality basic, strategic and applied research and related post-graduate training relating to the understandng and exploitation of biological systems;

— to advance knowledge and provide trained scientists and engineers which meet the needs of users and beneficiaries (including the agriculture, bioprocessing, chemical, food, healthcare, pharmaceutical and other biotechnology-related industries) thereby contributing to the economic competitiveness of the United Kingdom and the quality of life; and

— to provide advice, disseminate knowledge and promote public understanding in the field of biotechnology and the biological sciences.

3. BBSRC supports research underpinning crop biology, irrespective of its end use, and more directly on improving the potential of crops for non-food uses. Research is supported through responsive mode grants

to universities and academic analogues and through provision of the Competitive Strategic grant (CSG) to the BBSRC-sponsored Institutes.

4. Responsive mode grants are awarded through seven research committees. All but one (Animal Sciences) are in a position to support some aspect of plant biology. The Plant and Microbial Sciences (PMS) Committee also supports a Responsive Research programme (RRP) in Wealth Creating Products of Plants (WCPOP). The programme was launched with a call for proposals in 1995; applications are now accepted in responsive mode. The aims of this programme are to promote innovative research to overcome generic technological and scientific barriers to the economically favourable production of industrial product from plants. It is focused on the medium to high value product end of the market where there are significant opportunities for United Kingdom industry. It is expected that the potential for exploitation of the research is addressed in all grant applications and the inclusion of an economic analysis is encouraged.

5. BBSRC was a sponsor for the Crops for Industrial Use (CIU) LINK programme that funded 21 projects and came to an end in 1995 after five years. Other sponsors were MAFF, EPSRC, SOAEFD and DTI. Following on from CIU, is the LINK programme "Competitive Industrial Materials from Non-Food Crops" (CIMNFC) which is sponsored by BBSRC and MAFF with support on a "project by project" basis from DTI, EPSRC and SOAEFD. The programme began in 1996 with Government funding of approximately £4 million over five yeas. Whilst CIU tended to focus on the supply side, with the emphasis on alternative uses for existing crops, CIMNFC is directed at overcoming barriers to the uptake of crop materials by end-users on a range of industry sectors.

6. BBSRC is one of the sponsors for ACTIN (Alternative Crops Technology Interaction Network). ACTIN was launched in 1995 in response to an initiative of the National Farmers' Union and BBSRC. It is a collaboration between industry and Government and there are a number of industrial sponsors whose contribution over the first three years of operation was matched by BBSRC. ACTIN aims to stimulate the uptake of technology to meet the demands of new and existing markets for agricultural crops and to contribute to wealth creation in the United Kingdom by coordinating research and development and matching this to industrial demand. It is the United Kingdom's industry-led authority in the industrial crops arena and provides key events, publications and networking, this includes links to Europe (through IENICA and ERMA) and beyond. ACTIN is closely coordinated with the activities of the Alternative Crops Unit of MAFF and the two organisations recently combined their database of contacts. Mr Ian Bartle is the Director of ACTIN and the coordinator for the above LINK programme.

7. BBSRC sponsors three plant science institutes: Institute of Arable Crops Research (IACR), Institute of Grassland and Environmental Research (IGER) and the John Innes Centre (JIC), and supports research at Horticulture Research International (HRI). Work on non-food crops is also being undertaken at the BBSRC-sponsored Silsoe Research Institute (SRI).

8. This submission draws heavily on the report from the IENICA project prepared by ACTIN and funded by DG XII under the FAIR programme (February 1999). Also, the POST report "Alternatives in Agriculture—Growing Crops for Industrial, Energy and Other Non-Food Purposes" (January 1995), POST note 125 "Non-Food Crops" (March 1999) and on contributions from the BBSRC-sponsored Institutes.

What is the potential for the development of non-food crops in the United Kingdom? Which crops, if any are likely to prove significant in terms of economic activity or land use?

9. There is important potential for development of non-food uses of crops in the United Kingdom. This potential arises out of the need to replace less renewable resources and to find more environmentally friendly alternatives to current products and processes. Success of non-food materials depends on their cost, suitability for purpose and reliability of supply. Their competitiveness increases if they can provide novel or improved properties.

10. The Common Agricultural Policy has been a significant driver since non-food crops provide a means of making set-aside land productive. The affects of set aside and other subsidies make economic competitiveness difficult to assess, for example, in making comparisons to food crops.

11. The high value products are likely to prove most significant economically since they can be produced in small areas with limited effects on land use. As an example, crops grown for essential oils and other specialist products would require little land and some of these crops will be grown on land unsuitable for food crops. Potential uses include fragrances, pharmaceutical applications, aromatherapy, cosmetics, dyes and in pest control.

12. Oilseeds, rape (covering 28,000 ha in 1998) and linseed (100,000 ha in 1998), are the main non-food crop grown in the United Kingdom. Erucamide from high erucic acid rape (HEAR) is used currently in polythene manufacture. It is also used to produce behenyl alcohol which is added to waxy crude mineral oil to improve flow. Linseed oil is used in surface coatings, putty and linoleum. There are further opportunities for use in surface coatings, detergents, bioplastics, surfactants, emulsifiers and solvents.

13. Non-food products from conventionally high yielding crops, such as starch from wheat, have the potential to be economically successful in the shorter term (about 1 per cent of total wheat production is currently used for non-food uses). In the European Union, the paper and board industries are the biggest

users of starch and derivatives. However, there is also potential in the chemical industry with products ranging from biodegradable plastics to adhesives.

14. Biomass crops for energy and fibre have potential and are currently used within enterprise as waste or under the Non-Fossil Fuel Obligation (NFFO) scheme. They are likely to have a significant impact on land use (estimate of 100–150,000 ha for 10 per cent of the national electricity supply) though this could be alleviated to some extent by replacement of poplar or willow grown as short-rotation coppice (SRC) with fast growing grasses such as miscanthus. Economic competitiveness of biomass is currently limited by low world oil prices. Over the long term, economic success and commercial exploitation could be based on multiple usage.

15. It is suggested that fibre crops will be significant in the long term, provided production costs can be kept down, fibre characteristics can be made adequate for end use, and processing technology improved. Potential uses are in the paper, textile and composites industries. The United Kingdom has renewed its interest in flax and hemp, though the area for flax fell slightly in 1998 to 17,500 ha. There is likely to be competition from fibre produced in developing countries eg, jute. It is suggested that, to be successful, an integrated approach from grower to end-user is required.

What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg, by genetic modification of plants or plant viruses, or by advances in processing technology? Can problems of consistency and reliability be overcome?

16. Vegetable oils are already used as replacements for mineral oil, for example as lubricants and in the manufacture of surface coatings, and their potential as feedstocks for the chemical industry is likely to increase as oil prices rise. Plants can provide oils with different properties to mineral oils thus offering new opportunities. Oil crops clearly have the potential to pay their way, though vegetable oil-based materials are currently more costly than mineral oil-based materials. Another issue for the United Kingdom is competition from tropical vegetable oils, these are currently cheaper and of higher quality.

17. Biomass has the potential to replace less renewable resources but there are problems in establishment costs and with energy density, processing and transport. Biodiesel from oilseed rape or bioethanol from fermentation of sugar beet or cereals have been suggested as alternative vehicle fuels. However, they are unlikely to pay their way without subsidies or until world energy prices, currently at an all time low, rise.

18. There are a large number of possible end uses for carbohydrate crops. They have the advantage of being well adapted to United Kingdom conditions enabling high yields of consistent quality to be produced. United Kingdom industry is already looking into their use as alternative feedstocks.

19. Both conventional breeding and genetic modification offer opportunities to enhance the potential of non-food crops. They can be used as approaches to produce novel products, tailor crops to end-use or to overcome some of the current barriers to exploitation. For example, vegetable-based oils already have a role in the manufacture of polymers, but genetic engineering opens up the possibility of synthesising polymers in the plant. Opportunities to introduce new crops or to consider non-food uses of indigenous species might also be explored.

20. Improvements in product extraction and processing can also contribute to the development of non-food uses of crops. In the fibre industry, for example, there is scope for improved harvesting, storage and processing to ensure fibres of a suitable and consistent quality. If processing costs can be kept down then the potential to replace non-renewable resources is increased.

21. Crops are affected by environmental factors, pests and pathogens, which impact on both the yield and the quality of the product. For example, adverse weather causes pod shatter in oilseed rape reducing yield. Seasonality is also a problem, eg, fibre crops requiring storage of the raw material for long periods with the possibility of deterioration. Consistency and reliability is clearly a barrier to development of non-food crops, but could be improved through breeding and management or at the processing stage. Another issue for the manufacturer is the modification required to processing methodologies in order to use plant-derived products.

What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?

22. As noted in the POST report, the environmental and ecological implications will vary according to the type of crop, how it is cultivated and what it replaces (both change in land use and end product).

23. Many non-food crops require low inputs, for example, biomass crops need less nitrogen. Also, there is the potential to grow them on marginal land where there is currently less opportunity for crop diversification.

24. Replacing fossil fuels with biomass crops would contribute to a reduction in atmospheric CO_2 through reduced emissions and as consequence of the fact that carbon becomes sequestered in soil under willows and miscanthus. They can be planted on land, and with treatments, unsuitable for food crops. SRC sites are also seen to have ecological advantages over arable crops. One disadvantage is high water demand which may restrict their planting.

25. There is an opportunity to benefit the environment by using non-food crops to replace toxic materials or hazardous industrial processes. Crop-derived products are more sustainable, more biodegradable, CO_2 neutral and non-toxic. As an example, vegetable oil-based lubricants are being used in place of mineral oils in total loss or high environmental risk markets. However, crop derived products are not the only solution and manufacturers will look to other alternatives to address environmental concerns.

26. Genetic modification can open up the opportunities for non-food crops, but the environmental and ecological implications are not yet known. For modified rape, for example, there are issues around separating them from crops destined for the food chain to prevent contamination from cross-pollination or from volunteer crops.

27. Life-Cycle Analysis has been recognised as important in gaining insight into the likely value of non-food crops. For example, it is needed to prove that downstream processing doesn't use more energy than it delivers in value, in predicting change in agriculture, and in assessing competition with products derived from non-renewable resources.

Are there regulatory barriers to the development of non-food crops or disincentives in the current system of taxation and subsidies?

28. A number of non-food crops are likely to be genetically modified and, as such, there will be regulatory controls over their production and planting. This could be described as a barrier, but it is entirely appropriate that these controls are in place. Public concern about genetically modified crops, though currently focussed on food crops, is also likely to have an impact.

29. Depending on the nature of the modification it might be necessary to physically separate non-food crops and products from those used destined for the food chain and this will clearly have implications for the producer.

30. For speciality crops the regulatory and registration requirements vary according to end use ie food, medicinal or personal care. In some cases the requirements might act as a disincentive, for example, the cost of registering new compounds where the profit margin is small.

In the light of the above, (a) are the current United Kingdom and European Union subsidies for non-food crops, and the proposals under Agenda 2000, appropriate; (b) are the local, national and European Union regulatory regimes appropriate; and (c) is the level and direction of United Kingdom and European Union public funding for research and development appropriate?

(a) Most non-food crops receive some form of European Union support. CAP92 imposed mandatory setting aside of farmlands and many viewed this as an opportunity to develop crops for non-food uses. Concerns have been expressed that proposals under Agenda 2000 would reduce supplements to farmers who grow oilseed rape and that subsidies on other industrial crops eg starchy plants and non-wood fibres, could be removed entirely. Oilseed rape grown for food uses is more profitable than that for non-food uses, so any reduction in set aside is likely to reduce the area used for non-food crops. This would clearly have an impact on the vast majority of non-food crops which are currently uncompetitive without subsidies. The exceptions are a small number of the high value crops and some energy crops, though the latter get subsidies from elsewhere (NFFO).

(b) The regulatory regimes are broadly appropriate, but there needs to be greater recognition of the impact of the production of non-food crops on agricultural practice and on the possibility of mixing with food crops.

Legislation could play a significant role in the development of non-food crops if it impacted on existing materials and processes, eg through environmental or safety regulations, thus making plant derived materials an economically viable alternative.

(c) Increased levels of public funding would undoubtedly provide improved prospects for the United Kingdom to create wealth from non-food crops, but sponsors have to balance support for non-food crops against other calls on resources. There are a number of different funders providing resources to various centres carrying out research and a coordinated research effort is essential to provide appropriate support for industries based in non-food crops. Some efforts have already been made in this direction through the establishment of ACTIN.

1 April 1999

Supplementary memorandum by BBSRC (the Biotechnology and Biological Sciences Research Council)

ADDITIONAL EVIDENCE

Introduction

On 20 April 1999, representatives of BBSRC presented oral evidence to Committee. The Committee subsequently invited BBSRC to provide further information on the potential for production of pharmaceutical products in plants.

BBSRC Supported Research

BBSRC has supported four research groups to work in this area. These are listed below with accompanying text on the progress that has been made.

Investigator: Dr P W Goodenough (University of Reading)

Title: Production and analysis of a novel recombinant molecule for selective drug therapy.

Attached in an abstract provided by Dr Goodenough, produced by Carol Robertson, which describes his work.

Investigator: Dr N J Titchener-Hooker (University College London)

Title: Production of recombinant human and animal vaccines from plant materials.

This work was aimed at identifying and investigating key factors in the bioprocessing of virus material from cowpea leaves and predicting the performance of the process at large scale. The focus was on recovery of virus material from harvested leaves. The group has obtained data using leaves harvested from only two plants. It has investigated the process implications of using fresh and frozen leaves, different buffers and the impact of bath variability. It has managed to reduce the number of processing steps and make recommendations about choice of equipment. Work to consider process options and improve process efficiency is continuing.

Investigator: Dr G P Lomonossoff (John Innes Centre)

Title: Engineering of plant cells for the production of vaccines (green vaccines).

Dr Lomonossoff provided an overview, rather than an update on his own work.

The cost of production of pharmaceuticals in plants is likely to be far less than the cost of producing equivalent materials using fermenter (traditional manufacturing) technology. Given the huge biomass that can be produced from plants, it is quite possible that using plants in this way could result in the practical development of novel pharmaceuticals (eg vaccines) which are too expensive to produce conventionally.

In 1998, the first two human clinical trials with vaccines derived from GM plants were reported in the scientific literature, and results from further similar research is likely over the next few years. At present, all the research is done on a small scale under containment conditions. In the United States, plant biotechnology companies have already acquired farms to develop into pharmaceutical production facilities, working under controlled conditions as laid out by the United States Food and Drug Administration.

Novel processing technologies are likely to be necessary if the products are to be extracted and purified from the plants. However, there is the possibility that in certain instances purficiation may not be necessary, for example in the development of "edible vaccines". The limiting factor in this case will be the development of crops that produce high quantities of the desired speciality product and development of means by which to rapidly and inexpensively extract the desired product.

GM plants producing pharmaceuticals will undoubtedly pay their way. One example that is the nearest plant product to commercial realisation is a vaccine against tooth decay, and GM plants represent the only means available for production of this complicated vaccine. For other pharmceuticals, non-food plants can offer a much cheaper (and often safer) means of production as compared with methods currently available. The most obvious reason for this is the potential agricultural scale on which drugs and vaccines could be produced and the financial benefits that will result. However there are other significant technical advantages that will benefit the pharmaceutical industry. One advantage is that there is a broad similarity between the biochemistry of plant and mammalian cells. This allows the production of molecules, some of which could be made without the use of costly mammalian cell cultures, or even experimental animals. A second advantage is that plants do not host any human pathogens such as viruses or prions, which makes their use for phamaceutical production attractive on the grounds of safety.

Investigator: Dr S Santa Cruz (Scottish Crop Research Institute)

Title: Use of potato virus X for high level production of foreign proteins in plants.

May 1999

Memorandum by BICAL (Biomass Industrial Crops Ltd)

1. *What is the potential for the development of non-food crops in the United Kingdom? Which crops if any are likely to prove significant in terms of economic activity or land use?*

The directors and shareholders in our company, BICAL, are mainly United Kingdom farmers, all too well aware of declining profits from food production, and they need to find alternative profitable non-food crop production. This was why we set up the company. A total United Kingdom estimate of arable land surplus to food requirements by year 2015 is two million hectares, and for the European Commission as a whole 20–40 million hectares (Grassi and Bridgewater 1992).

Our members have concentrated on the commercial development of miscanthus parallel with 10 years field experience and trials work carried out by ourselves, ADAS, MAFF, DTI/ETSU and others. In fact state-funded research on miscanthus has been minimal compared for instance to that on SRC willow and poplar, in part because there have been so few development problems (see Review of Research on Biomass Crops, MAFF, May 1998). The first work funded was a feasibility study entitled *The Potential of Miscanthus as a Fuel Crop,* ETSU B1354, 1992. That document has served as an excellent guide to crop development, and virually nothing has happened since that could not have been forseen from the contents.

Consequently we anticipate a very substantial commercial crop area of miscanthus, mainly in the South and West initially, within five years. Our conviction, demonstrated by significant capital investment from over 20 farmer shareholders, is based on:

(a) *High yields in ADAS and our own trials,* often double those of SRC. Evidence is provided by reference to yields reported in for instance Biomass and Energy Crops AAB Aspects of Applied Biology 49. We expect commercial yields with our existing genotypes to be in the range 10 to 20 tonnes dry matter per hectare. For further evidence see again the MAFF Review of Biomass Crops referred to above.

(b) *Easy and low cost to grow, robustly tolerant* of a wide range of growing conditions. Evidence is provided in the ADAS Arthur Rickwood reports for MAFF, and our own experience on over 15 sites. After the initial establishment, which requires care and pesticide input, management has been extremely easy with minimal, and low cost input of pesticides and fertilisers. It is a crop suitable for most farmers, even in grassy livestock areas. We have developed low cost planting techniques, with support from ETSU/DTI. Both planting and harvesting can be with existing farm equipment.

ETSU/DTI. Both planting and harvesting can be with existing farm equipment.

(c) *Propagation Material Supply.* Our company has built up significant stocks of rhizome, and of high yielding types which can be grown from seed, allowing rapid expansion of the crop area. We have the exclusive rights to sell new varieties and other stocks owned by Tinplant GmbH, who are breeding new types with European Commission funding, and are micropropagators. We also possess rhizome stocks in warm temperate lands, and anticipate signifcant sales in the United States of America and elsewhere. BICAL is in a pivotal position for supply of miscanthus throughout the northern hemisphere, which will offer substantial benefits to the United Kingdom economy with BICAL as an exporter of both technology and rhizome.

(d) *Profitable End Uses.* Concurrent with propagation stock expansion we are developing many diverse and substantial new markets for miscanthus. For instance, our trials with chopped miscanthus indicate it offers clear advantages as poultry and equine litter over more expensive materials like wood shavings. Furthermore, we can demonstrate how miscanthus can be more profitable than winter barley production, with significant benefits for the environment arising from its lower requirements for cultivation, artificial fertilisers and agrochemicals.

We are actively seeking to acquire existing NFFO contracts, to generate electricity from miscanthus, at prices that are profitable for the farmer producer. We are working closely with other NFFO contract holders, to help ensure fuel crop supply. There is some limited evidence to suggest that miscanthus cannot be gasified because of slag formation from the silicon. This is not so given accurate design of the gasifier for the fuel used. Thus in fluidised sand beds it is no problem. In pyrolysis it is no problem because the temperatures are too low for slagging.

We have a very high value niche market, a new end use, with global sales potential. Product manufacture is expected to start later this year. Several other niche market products are under development.

We have a very close association with the Advanced Technology Centre at Warwick University, which is likely to lead to several new products, some for the motor industry, others for building construction. These could offer significant benefit to the economy in employment terms, as some would directly replace current imports, competitively.

Another use is being developed, by South West Water, with European Commission and ADAS support, is for composting sewage sludge, with widespread applicability in United Kingdom and overseas. This again could offer considerable environmental benefits over other methods of sewage disposal. Other uses we have been developing for several years include thatching to replace imported water reed. Our thatch is cheaper, and probably lasts longer. We are also developing and have sold, miscanthus as cover for wild birds and game.

We are working closely with Chempolis Oy, of Finland, to build a novel process paper pulping plant with miscanthus as feedstock, in United Kingdom or overseas. This process gets round the problem of silicon deposition, which hinders use of grasses for pulping, by an elegant chemical solution. It is environmentally very sound, and capital cost is moderate. A description of the process is given in the IENICA Newsletter October 1998. This opportunity offers significant benefits to the United Kingdom economy, were we to succeed in persuading that company to construct its first plant in England or Wales. The United Kingdom utilises 1.5 million tonnes of paper pulp per year, in 129 paper mills. The pulp is nearly all imported. We have close associations with other companies overseas that are developing other new uses for miscanthus, and particularly expect to see significant developments in the United States of America. These examples clearly demonstrate the significant potential of miscanthus as a major United Kingdom crop, because of its great flexibility and diversity of industrial uses for energy and fibre.

In summary, miscanthus crop yields are high, it is easy to grow, commercial end uses have already started, and will now develop rapidly. This crop has potential for many thousands of hectares in United Kingdom.

2. *What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg by genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability be overcome?*

(a) Replacement of other less renewable resources

All of the end uses we are developing for miscanthus do this. Thus uses replacing wood from trees are beneficial because trees are less easily and quickly renewed than miscanthus, which regenerates from rhizome naturally, annually. Thus uses of miscanthus for pulping, chipboard MDF and other novel boards are all more beneficial. We are aware from our associates in the United States of America of the potential environmental disaster in that country arising from large scale forestry chipping, not giving time for regeneration. Use of miscanthus will reduce the need for this. As wild bird and game cover, miscanthus substitutes for expensive annual kale crops which require heavy fossil fuel inputs as fertiliser and considerable need for pesticide.

Several new end uses are replacing plastics, which require fossil fuel use in manufacture. We are developing a range of products in this category, for packaging, engineering and constructional uses, often involving making composites, or mixing with other plant-derived materials. These and the other fibre uses may be more effective carbon sequestrators than uses as fuel.

Biomass as fuel is generally considered carbon dioxide neutral, and thus beneficial in saving fossil fuels. The energy input:output balance for miscanthus production is very high because chemical inputs are low and harvesting inputs are lower than for trees and coppice. BICAL lacks the resources to make specific assessments ourselves, but can supply data.

(b) Non-food crops to pay their way . . .

All the end uses that we are developing for miscanthus are intended to pay their way from the start of production, in the near future, not just in the long term.

(b) Enhancement by genetic modification

Miscanthus is at the same stage of genetic improvement as cereals several thousand years ago when hunter gatherers first started selection of improved types from seed. Mass selection from the widely varying genotyes of M sinensis, and M sacchariflorus, is extremely easy, and rewarding, as we have been able to demonstrate with our first improved types. Other workers in Scandinavia and Germany are also making progress this way. So far as we know, the only systematic breeding programme using advanced techniques is that being conducted by our close associates Tinplant GmbH in Germany, with European Commission funding, to produce improved clones of miscanthus x giganteus for use in northern Europe. We intend, in collaboration with Tinplant to widen the scope of this work to produce types suitable for warm temperature, and tropical climates. None of this work involves GM techniques.

(c) Advances in processing technologies

Much of the work on product development outlined above involves developing methods for processing miscanthus cane. This is fundamental to utilisation.

(d) Consistency and reliability issues

Yield consistency and reliability has been studied by ADAS on a range of sites in the United Kingdom. The term "Robust" has been used by ADAS in several reports describing the crop. As with all crops there is seasonal variation in yield, particularly related to rainfall and soil moisture capacity. This work, and longer term studies in Germany, indicate that peak yields are reached in the third and fourth year after planting,

when a yield plateau is reached which continues for many years. The oldest field in Germany is at least 14 years old, and there is no sign of yields falling off, although there is annual variation. In Japan there are miscanthus dominant grasslands hundreds of years old. As a herbaceous plant, continually renewing itself by the formation of new rhizome, longevity should be very considerable with good management. The crop is not susceptible to the stool base diseases causing such difficulties with coppiced willow and poplar. We have grown the crop on sites from over 300 metres altitude down to sea level on a wide range of soil types with reliable consistent results and we can go some way towards forecasting yields in particular situations. Perhaps the optimal situation for miscanthus is lowland southern England, medium and heavy soils. But we also have some good results north of the Bristol Channel, and have observed that moisture can compensate for temperature. We would expect miscanthus to yield well wherever maize does. This would include the flat parts of Cheshire for instance, and river valleys even further north. Miscanthus is more cold tolerant than maize. Rhizome mortality has been reported in the first winter after planting on the continent of Europe, but only in places with long periods that are much colder than anywhere in England, and only with miscanthus x giganteus, not miscanthus sinensis. So far pest problems are slight (although rabbits may be harmful during establishment) and diseases negligible. It seems reasonable to expect a lengthy honeymoon period free of disease problems, as for maize. This subject is well reviewed by ADAS in ETSU B1354. Moisture content of the cane at harvest in late winter is quite variable, according to weather and variety. Any problems of consistency and reliability should be susceptible to improvements in crop management and breeding.

3. *What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?*

(a) Environmental and ecological implications

Miscanthus cane used as a substitute for fossil fuels has environmental benefits as described earlier. When grown in place of annual crops there are environmental benefits by reducing fossil fuel use, reduction of nitrate leaching, soil stabilisation reducing erosion, enhanced carbon dioxide capture, provision of habitat for animals and potential for an under flora. Compared to C3 pathway crops, perennial and annual, the C4 pathway miscanthus is fundamentally beneficial by enhancing nitrogen and water use efficiency, as described in ETSU B1354. Although the crop is very new to northern Europe, it is already providing habitat to birds, mammals and insects. Under flora are developing in some situations. The appearance of the crop fits well into our scenery, in particular the autumnal colours of the maturing leaves and cane match well with surrounding woodlands. Little systematic work has been done on miscanthus, current status is described in the MAFF Review of Biomass Crops 1998. Clearly environmental acceptability is desirable for large scale production.

(b) Life-Cycle Analysis

This is beyond the resources of our company, but we would be willing to provide data to analysts.

4. *Are there regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?*

(a) Current support for miscanthus cropping

In United Kingdom, and all the European Commission countries, miscanthus can be grown on set-aside land, with growers countinuing to receive the set-aside payments. This with the proviso that the end uses are permitted, as defined by the HM Customs Combined Nomenclature codings. Our study of these suggests that most if not all our intended end uses for miscanthus would be permitted. However, this hardly qualifies as support for miscanthus because set-aside payments are made whether or not miscanthus is grown on the land.

(b) Current support for other crops and livestock enterprises

All ruminant livestock enterprises receive substantial support in various ways, whether or not they are on land which is part of the Arable Area Payments Scheme. No support is given to grow miscanthus on land not part of the Arable Area Payments Scheme, that is mainly grasslands supporting livestock enterprises, concentrated particularly in the western half of the United Kingdom, where biomass crops would grow best. No Planting Grants are given for miscanthus, such as those for short rotation coppice and forestry. No tax benefits are provided as they are for forestry. All agricultural food crops and ruminant livestock enterprises continue to receive specific European Commission aid in many forms, but Miscanthus attracts no current support. Some non-food crops like flax, hemp and oilseed rape get specific European Commission support, but miscanthus, nothing.

(c) Consequences of lack of support for miscanthus.

The lack of support is a gross distortion of free-market economics, and has inevitably hindered the development of commercial acreage, and the country is poorer for it. In fact it may be considered amazing that our company dedicated to developing miscanthus exists, disadvantaged and penalised by several hundred pounds Sterling per hectare of crop grown per year, compared to any other crops suitable for wide-scale farm production. It is only due to our recogniton of the inherent advantages of the crop and farmers' instinctive recognition that it is the sort of crop they would like to grow, that we have persevered despite Government inertia in the face of our protestations of injustice. We also know that if the crop is right it will become widely accepted and grown, because artifical economic barriers always collapse in the end.

5. *In the light of the above . . .*

(a) Are the current United Kingdom and European Union subsidies for non-food crops, and the proposals under Agenda 2000, appropriate?

No. Parity of support between all crops, food and non-food, is necessary to provide free undistorted competition. In particular support for miscanthus is only needed to enable it to compete on a level playing field against other fuel/fibre crops already grant aided. Let the market decide what to grow, but let it be a free, undistorted market. There appear to be no proposals under Agenda 2000 for the recognition of non-food crops as a group for support. Surely with millions of European Union hectares surplus to food requirements, major alternative agricultural land uses, that are environmentally beneficial, should be given every opportunity to express their economic potential

(b) Are the local, national and European Union regulatory regimes appropriate?

Our national regulatory regime is not appropriate for miscanthus. We are informed by the European Commission DGVI that if miscanthus is grown for energy purposes, on set-aside land: "Member states are authorised to pay up to 50 per cent of the costs of establishing multi-annual crops intended for biomass production on set-aside land". Our own MAFF pays nothing for miscanthus establishment, because, as they have stated, the only funds they have available for this are dedicated to forestry which includes SRC. So for botanical reasons, miscanthus is discriminated against and has to compete against coppice and forestry that receive hundreds, or even sometimes thousands, of £ Sterling per hectare grant, and Treasury tax breaks.

The European Union regime fails to recognise the potential role for non-food crops as a group in utilising land surplus to food requirements. It should consider operating a Non-food Crop Group Support Scheme, recognising fibre uses as well as energy, supporting each crop on an equivalent basis, related to establishment costs. For miscanthus this is only needed whilst support is given for other less competitive and flexible crops.

(c) Is the level and direction of United Kingdom and European Union funding for research and development appropriate?

A higher proportion of funds should go to non-food crops and their uses, rather than food crops, because they represent a major future growth area.

The European Commission and United Kingdom Government money invested in miscanthus has been minuscule compared to that for SRC, but it has we believe a much brighter future.

Most agronomic problems, beyond basic research needs, can be solved as efficiently by the growers and their commercial suppliers as by Government funded work. State R&D funding should be directed more to developing novel end uses for the industrial crops. Industry often has no incentive to bring in sustainable renewable replacements for existing (fossil fuel based) products. This must therefore be the role of Government, which it can fulfil by funding the development of new products with industry, R&D organisations with the closest links to industry are the most worthy of support. We intend our relationship with the Warwick Advanced Technology Centre, and other research organisations, to lead to State funding for product development, but we have managed so far without.

March 1999

Memorandum submitted by Chung-Wai Chiu (Supplementary memorandum from ICI)

JOHN INNES CENTRE VISIT

I have discussed your question with our "biodegradables" marketing manager. At this point, starch based products are cost competitive in the "destructible" foam area. The comparison is on a cost per cubic foot basis. For example, ECO-FOAM at 0.50 lb/cu ft is approximately equivalent to EPS (expandable polystyrene bead-based) loosefill. We believe starch based foam in general will be cost favorable in the foam sheets or other molded foam products. Although our sale is increasing, price is always the first factor manufacturers need to consider. Unless Government has set a very restrictive environment requirement, consumers are

unwilling/unable to pay a higher price for the products. In Europe, the situation is even more favorable in certain countries where user fee and disposable fee are charged for petroleum based products.

The total biodegradable (destructible) foam market is estimated about 2-3 billion dollars at this time (caution: not sure how accurate this number is because it is very difficult to get correct information!!) The economics is less favorable in the case of non-destructible or high density type products which are based more on $/lb basis versus $/volume.

I hope this will be of help to you.

Chung-Wai Chui
4 May 1999

Memorandum by Body Shop International plc

My sincere thanks to Lady Hogg, the other Sub-Committee Members and yourself for enabling me to deliver my evidence in a timely manner last week. As a result I was also able to keep my appointment with the BBC and the resultant interview was broadcast on the lunchtime news and Children's Newsround.

Despite the literally alarming delay of the fire practice, I felt I was able to cover the key points in my presentation and answers to Member's questions in the 30 minutes provided. During that time I made two commitments to providing the Sub-Committee to provide further information.

The first was to provide a reference for my statement that there are 25,000 potential commercial uses for industrial hemp. The reference comes from an American publication, *The Emperor Wears No Clothes—The Authoritative Historical Record of the Cannabis Plant, Marijuana Prohibition, & How Hemp Can Still Save the World,* by Jack Herer. In the book Mr Herer makes reference to a leading magazine published in America called *Popular Mechanics* which describes Hemp as "the billion dollar industry" and being capable of producing "more than 25,000 products, ranging from dynamite to Cellophane". We believe these to be the first references to the economic potential of Hemp and its substantial versatility.

The Sub-Committee's second request was for clarification as to why The Body Shop source our lanolin outside of the United Kingdom. Our lanolin is sourced through a Yorkshire based company entitled Westbrook Lanolin. The brief to the company is to provide high quality lanolin from sheep that are kept for their fleeces and treated in an humane manner.

The former requirement pushes us towards the Marino sheep and away from breeds kept commercially in the United Kingdom which have much shorter coats and are bred for slaughter.

Animal welfare considerations also guide our decision-making and we sought advice from a number of groups including the United Kingdom-based Compassion in World Farming organisation. After an extensive trawl through available data, advice from animal welfarists and the lanolin supply industry, we opted for a supply from South Africa.

I trust this information will be helpful to you and the Sub-Committee and wish you success in your important work.

12 July 1999

Memorandum by Dr Steve Bowra

EXECUTIVE SUMMARY

In summary the issue of non-food crops has been debated for many years currently linseed and oilseed rape are the two most important non-food crops, with flax and hemp receiving interest if, for no other reason, than they attract a large subsidy. Industry has been encouraged through link grants to flirt with the idea of non-food crops with the aim of improving their bottom line. The overall result is that little real progress has been made over the last decade towards the appropriate evaluation of industrial non-food crops and in particular alternative crops. There appears to be enormous inertia blocking the development of non-food crops. Agriculture in the United Kingdom and Europe is in a critical stage of reassessment. The European Union Agenda 2000 sets out proposed reform of the common agricultural policy, which will open European and United Kingdom farmers to worldwide competition/market forces. However the European Union agricultural reforms also bring greater decentralisation and therefore freedom to develop agricutural policy appropriate for the United Kingdoms unique conditions. The United Kingdom farming community is facing financial and social problems the average age of farmers is now 58, the industry is failing to attract new blood to both continue the long tradition of agriculture expertise and also invigorate with new ideas. I believe it is important to actively grasp this opportunity and create an integrated policy for agricultural development in the United Kingdom that is in line with central Agenda 2000 proposals. This must place non-food crops at the center of a socio-economically and environmentally responsible plan which fosters the potential of non-food crops not only to provide renewable industrial feedstocks but also stimulate the processing/manufacturing industry to design and develop new and alternative uses of the raw material which meet the consumers needs. This goal can only be achieved through focused directed research that is appropriately funded, something that does not currently exist.

BACKGROUND

To set the following discussion about non-food crops into context, it is of value to summarise the points stated in the introduction of the POST Note *Non-food Crops* 1999. Prior to the development of the petrochemical industry, agriculture played a principle role in supplying materials for industry: eg vegetable oil for soaps, flax and cotton for weaving etc. Therefore, historically, the non-food crops have proven potential to meet industrial needs and it was only the drive to find a cheaper more efficient source of raw material that led to the demise of industrially important crops. It is also argued that the exponential increase in the human population during the industrial revolution necessitated the utilisation of all agricultural land for the production of edible crops. Continuing with the historic perspective, we can perhaps view the current rapid developments in Ag-biotech as similar to the revolution seen in the late 19th and early 20th century. These recent developments in agriculture not only have the potential to increase global food production but also may profoundly alter society, civilisation and the ecological balance and if we add non-food crops to the equation, the bases of the world economies may also be changed. What is the basis for such a conclusion?

Firstly, the current wave of transgenic plants have focused on herbicide and insect resistance, reducing the level of crop husbandry required, with the concomitant beneficial effects on ecology and improved productivity. The long-term goal is to reduce other inputs such as nitrogen, phosphorous and develop increased tolerance to abiotic and biotic stress, eg drought, salt. This will result in less intensive agriculture for the highly productive European and United States farmers, and allow the use of land for crop production by those communities currently dependent on extensive/subsistence agriculture. Coupling these developments with improved outputs, ie quality, yields and post harvest storage, then the next wave of Ag-biotech revolution will have significantly improve the probability of meeting global food requirement.

Secondly, as a consequence of the goals of the current Ag-biotech revolution, the regions that are highly productive will remain so but will probably achieve enhanced output from a smaller agricultural landmass. Those regions of the world yet to become agriculturally self-sufficient will be enabled to achieve this first step in economic development. The social stability and subsequent economic development of China is often cited as an example of the link between self-sufficiency in food and the first steps towards economic development. Therefore the outcome of a country becoming self sufficient in food production is that the economy and society matures/develops. This in-turn shapes the complexion of the country from one of importing food towards one of importing consumer goods.

The argument that the global population will vastly exceed our ability to provide food has been repeated many times through our history and each time it has failed to materialise. While providing food is a major thrust of Ag-biotech it will not only provide food to maintain the expansion of the global population, but provide the platform by which the current disparity between the economically developed and the under developed communities/countries will be eroded. Thus, once fed, demand increases for consumer goods, development of the infrastructure etc. This would place pressure on an ever reducing non-renewable industrial feedstock. Hence the real future need is not going to be food but industrial raw materials that will facilitate development of new emerging and old societies, in a way that is environmentally, ecologically and socially responsible. I believe the emphasis must be on sustainable renewable resources that have near neutral ecological impact, thus non-food crop research and development is fundamentally important.

I have purposely placed the discussion at a global level. Whilst acknowledging the sub committee remit is to take evidence on non-food crop production in the United Kingdom, I feel it is important to place any strategic planning/thinking/discussion in a global context, especially as we are experiencing increased globalisation at all levels of society and industry. Ag-Biotech is no exception, as shown by the recent controversy relating to GM foods imported from United States of America. In the light of this background I will address the questions set out by the Committee.

1. *What is the potential for the development of non-food crops in the United Kingdom?*

Repeatedly over the last five to six years, both MAFF and European Union reports have been produced which have identified many potential new crops that could provide a range of novel oils, starches, fibres and proteins for industrial use both in the United Kingdom and Europe. The reports are largely surveys and the analysis of viability is usually assessed based on comparison with existing industrial feed stocks, which are unsustainable or renewable. I believe the potential has been identified repeatedly; what is required is a fundamental change in the driving force behind the development of alternative crops. Unfavourable economics should not preclude development. The auto industry provides a good example, for a number of years the industry has come under increasing pressure from environmentalists to reduce toxic emission from combustion engines. The challenge has slowly been met, leaded petrol to unleaded, catalytic converters, battery powered vehicles and most recently vehicles powered by fuel cells. The latter was not developed by the industry but by a small engineering firm. This illustrates two points; first, most large industries are lead by the bottom line and therefore economics dominate research and development and rarely if ever put socio-economic/environmental factors into the budget. Secondly, the development of the fuel cell was carried out despite the economics, the cell is still very expensive to produce, therefore whilst the underlying motive was no doubt financial, the driving force would appear to be socio-economic/environmental. I would suggest that to realise the clear potential of alternative crops, a similar driving force needs to be created. Drawing from examples of Japanese marketing strategy, which over the last 10–15 years has been used to diagnose the

decline in the western industrial competitiveness, the main factor that is repeatedly illustrated is western business management insistence on short-term profit and achieving substantial market share; the two objectives are not compatible. Most leading marketing academics would now advocate identifying the target customer and segmenting the population to identify the benefits that motivate the purchase. I would suggest that the limited number of cost benefit analysis and Life-Cycle Analysis of non-food crops have been constrained by financial considerations in terms of the industry rather than the consumer. Using the argument that the consumer will resist price rises is not substantiated, as evident by the continued consumption of petrol despite the ever-increasing price. Therefore, the potential is evident; however, the driving force has yet to really develop, perhaps it would be prudent of policy makers to act before being pushed and cornered by and ever informed/concerned public. This raises the vexed question about the role of Government does it lead the country or respond to the populace? Some might say it is a combination. From the general theme of the questions the combination seems the approach to this issue. Such lofty ideals fall flat without establishing an overall policy to provide clear overall objectives that allow the many component parts to work together towards the goal. Those who argue against Government intervention (I would rather use direction) fail to acknowledge the ever present defense policy. Agriculture is central to the United Kingdom, with something like 75 per cent of the United Kingdom under agricultural practice, it seems likely that a large number of the United Kingdom population are affected by agricultural at some level. Therefore, why not have an agricultural policy akin to the defense policy? I would hope the purpose of this enquiry is to provide the bases of such set of guide lines.

1(a) *Which crops are likely to prove significant in terms of economic activity and land use?*

In addressing this question I will direct my focus towards alternative crops rather than speculating on the development of genetical modification of existing agronomically important crops to create industrial feed stocks. The domestication of alternative crops has the following advantages:

(a) the trait of interest is already expressed in the plant;

(b) the introduction of alternative crops increases the agricultural crop basis;

(c) the introduction of alternative crops promotes ecological diversity;

(d) reducing the possibility of horizontal gene flow;

(e) reduces the problem of segregation/compartmentation of identical seeds with different traits;

(f) could promote beneficial effects of crop rotation;

(g) possible overall reduction in agricultural inputs, at the very least crop to crop variation;

(h) enhance the development of integrated crop management systems;

(i) renewable industrial resources;

(j) sustainable industrial resources;

(k) near neutral carbon balance during production and processing.

Whilst the advantages can be identified, the economic activity and land use has yet to be thoroughly assessed through the use of socio-economic/environmental, Life-Cycle Analysis (LCA) and cost benefit analysis (CBA). However, in the absence of the appropriate analysis/data, it would appear the debate grinds to a halt. This is, of course, only if you accept the financial constraints as the basis for promoting non-food crops. If on the other hand, the socio-economic/environmental issues are the motive forces, the information derived from LCA/CBA etc will provide an insight to where the current bottlenecks exist and provide a focus for further R&D and not the basis for creating a case for stopping the development. Future development has to be accepted as default and the questions should be how not should we? The recent clear statement from Dupont that they ar moving to plant derived industrial feed stocks should wake up the United Kingdom and European Ag-biotech community.

A number of candidate plant species have been identified for a comprehensive list the reader is referred to the NF-AIRID project report.

2. *What is the potential to replace other less renewable resources, and pay their way in the long term? Can this be enhanced, eg by genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability be overcome?*

I believe the question should be how non-food crops will replace non-renewable sources of industrial feed stocks, not could they. Once the socio-economic/environmental forces are driving the initiative, the development of new plant breeding strategies around the rapidly developing high through-put technologies associated with agricultural functional genomics will expedite the development of new improved breeding lines that exhibit an improved agronomic phenotype. As a direct consequence, problems of consistency and reliability will be addressed during the breeding programme. In parallel with the breeding programme, the processing technologies should be developed. To facilitate the down stream separation and subsequent processing of an initial feed stock which may have more than one important by product ie fibre, protein, oil,

natural antioxidants and other secondary compounds. This again broadens the scope for non-food crops. Clearly the whole initiative has to be viable without financial intervention. To achieve financial independence adequate funds need to be made available for focused research and development.

3. *What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?*

The environmental and ecological implications have not been formally assessed for the introduction/development of alternative non-food crops. However, the very fact that non-food crops are renewable and many of the products derived from them are biodegradable must weigh in their favour. It is noteworthy that what would seem to be the major issue driving the development of non-food crops has not received any attention, as is evident from the similar statements in the 1991 and 1995 House of Lords special committee reports. Indeed in the 1999 POST the need for LCA was emphasised but no information was available. The cost benefit report commissioned by MAFF is still being processed and was primarily concerned with OSR and linseed, flax and hemp. Having spent the last ten years deciding the LCA should now be carried out I hope we will not spend another ten years deciding how.

4. *Are there regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?*

To address this point it is worth qualifying the term non-food crops. Firstly, whilst obvious it is worth stating that these crops are plants and as such should be subject to rigorous scientific assessment and investigation as to their impact on the ecosystem when introduced on large scale. This is of course a long term process and whilst the same questions should be directed toward the introduction of both GM plants and alternative crops, the latter have the considerable benefit, as in most cases there have been cultivated for hundreds of years as secondary crops eg coriander. Therefore non-food crops should be subject to same scientific rigors as applied to any newly developed crop species. I would like to emphasis an important point here, I am concerned that the drive to unify plant genomes (synteny between monocots and dicots) will lead to a dilution of the individual uniqueness of every plant in turn promoting generalisations about crop plant interaction with the ecosystem. It is extremely important to assess each line as a separate entity and therefore develop assessment schemes that are directly related to the plant before assessing its impact. Therefore the issue of regulations should be seen as fluid and not static because they should be continually updated in the light of new information derived from asking new and more exacting questions.

The development of alternative non-food crops will not initially require genetic modification. Thus the current restrictions applicable to GM crops will not prohibit the development and introduction of alternative non-food crops. This point is perhaps important in the light of the need to diversify agriculture sooner rather than later given the crisis agriculture finds itself in. Although there are not identifiable tax disincentives there are no incentives. However, I feel it is perverse to suggest that incentives might help the process of developing non-food crops when I feel the issue is one of socio-economic advantage thus the whole of the United Kingdom ultimately benefits.

5. *In the light of the above (a) are the current United Kingdom and European Union subsidies for non-food crops, and the proposals under the Agenda 2000 appropriate; (b) are the local, national and European Union reglatory regimes appropriate; and (c) is the level of and direction of United Kingdom and European Union public funding for research and development appropriate?*

Clearly the reforms to the CAP under the Agenda 2000 proposals will reduce the subsidies payment via the AAPS. Although this has provided support for non-food crops it is hardly as part of a directed and concerted policy. This fact is reinforced by the lack of any explicit mention of non-food crops in the Agenda 2000 memorandum or in the CAP reform proposals impact analysis. However, the emphasis on agricultural diversity provides an opportunity to promote the utilisation of non-food crops and still remain within the guidelines provided by the Agenda 2000 proposal. The absence of emphasis on non-food crops would appear to indicate the combined lack of directed research and development, or at the very least successful examples. Whilst Framework 5 continues to promote R&D in line with industrial needs. It is interesting to compare the United Kingdom support for non-food crops. Information taken from POST 1995 states the United Kingdom Government supported R&D through MAFF, SOAFD etc. In 1999 the MAFF budget for non-food crops will be £3 million of a total budget of £124 million (2.4 per cent). £22.5 billion on defense £3 million on non-food crops.

Thus to conclude, non-food crops despite their potential to revitalize United Kingdom agriculture have failed to attract appropriate research funding and strategic support. I hope that the sub-committee will find enough evidence to promote non-food crops as part of United Kingdom agriculture policy that aligns itself with the Agenda 2000 proposals.

PERSONAL NOTE

The evidence presented is completely independent and forms part of my own personal opinion.

Dr Steve Bowra

21 May 1999

Memorandum by the British Embassy, Washington DC, United States of America

DRIVING FORCES

I spoke to Dr Frank Flora, National Program Leader for the Agricultural Research Services "New Uses" Programme. Flora identified a number of factors, driving United States interest in the development of non-food crops:

- the 1996 Farm Bill, which introduced decoupled, digressive and time-limited subsidies, is driving a restructuring of the United States agricultural industry. This has generated considerable interest in developing new uses for commodity crops to provide income for farmers;
- to make biomass a viable market competitor to imported oil, to reduce United States dependence on foreign imports;
- to stimulate rural economies and revitalise rural areas by developing new markets and revenue streams;
- to replace non renewable energy sources with renewables; and
- to develop new technologies which are more environmentally friendly; by reducing emissions of NOX, SOX and other pollutants, and by decreasing greenhouse gas emissions.

Flora said he was not aware of any specific subsidies for non-food crops, but highlighted that a few states had introduced tax incentives to encourage the use of ethanol as a fuel.

CURRENT RESEARCH

(a) *United States Department of Agriculture (USDA)*

The USDA funds some $40 million of research into crops for non-food uses and for bio-energy and energy alternatives. This work is funded through both USDA's intramural programme through the Agricultural Research Service, and its extramural programme through its Co-operative State Research, Education and Extension Programme. The USDA programme is subdivided into:

- new uses, which is focused on developing new technologies to convert commodities and processing bi-products into important value-added products such as fat substitutes, high quality animal feeds, improved textiles, pharmaceutical ingredients, enzymes and cosmetics, as well as the development of new high-value bio materials such as bio-degradable plastics, adhesives, and lubricants;
- bio-energy and energy alternatives, which focuses on developing technologies to reduce the cost of producing ethanol, in particular developing new enzymatic processes for saccharification and improved micro organisms to ferment the multiple sugars found in biomass, as well as bio diesels as fuel additives or alternative fuels. The relatively high cost of ethanol production and the very high cost of bio-diesel production remain important constraints on their use.

Some examples of projects currently being funded through the Agricultural Research Service, including the soybean ink project, are attached, Annex 1 (*not printed*).

(b) *Department of Energy (DOE)*

The DOE spends some $100 million per year in agricultural related R&D through its Office of Energy and Efficiency and Renewable Energy and the Office of Science. DOE's programme focuses predominantly on biomass for fuels, power and industrial products. In February 1998, the Department launched its vision for the biomass industry—"Plant/Crop Based Renewable Sources 2020". This vision calls for a national partnership between private industry and the federal Government to:

- displace at least 10 per cent of petroleum with plant/crop resources as the basic building block for consumer products by the year 2020, and provide the concepts needed to displace as much as 50 per cent by the year 2050;
- to establish a plant/crop based manufacturing infrastructure; and
- establish partnerships between industry, Government and academia for the R&D needed to achieve market opportunities and to ensure that processes and systems are commercially viable.

A group of representatives from industry, Government, academia, trade associations and non-profit groups, developed a technology roadmap (copy attached, Annex 2) [*not printed*] to identify the critical

pathways for research and development needed to obtain the goals outlined in the vision. In February this year, the DOE received an additional $2 million to begin the collaborative R&D identified in this roadmap. The first awards under this programme are anticipated on or about 1 August 1999.

(c) *Industry*

United States industry is also involved in developing new products from agricultural commodities. In February 1998, the United States Department of Agriculture and the United States Department of Energy signed a Memorandum of Understanding (MOU) with a number of agricultural producers groups and companies aimed at stimulating R&D in promoting product development from crops, including the American Soybean Association, the National Association of Wheat Growers, the National Corn Growers Association, JR Simplot, a potato growers conglomerate based in Idaho, Corn Refiners Association, DOW, Genencor, International Polyol Chemicals and Monsanto. This Agreement will be in effect initially for two years, but can be extended. The high number of private sector participants in this MOU indicates the extent of industrial interest in this developing area.

Philippa Rogers
First Secretary, Science and Technology

12 July 1999

Memorandum by British Sugar plc

The Government should encourage the development of an agricultural and industrial infrastructure to encourage the production of fuel from renewable resources and to help in meeting our Kyoto Treaty targets.

Part of the future competitiveness of United Kingdom agriculture will depend on its willingness to diversify into non-food areas.

Supporting agriculture in the production of biomass for fuel production is both environmentally sounder and fiscally more prudent than direct farm subsidies.

In the European Union there are several countries which are far ahead of the United Kingdom in the creation of pilot scale projects because of the provision of Government assistance.

British Sugar is examining a number of applications for non-food crops and has a particular interest in new technology for the conversion of biomass to alcohol. This new technology has the potential to double yields from biomass compared with traditional processes.

British Sugar has the logistical experience of handling large amounts of agricultural produce (nine million tonnes of sugar beet) and large scale process engineering expertise. This places the company in a unique position with regard to the exploitation of future opportunities for non-food crops.

World oil stocks are dwindling while concerns over global warming continue to grow. As a result the search for alternative, preferably renewable, feedstocks to support both industry and our love for motor cars must intensify. Additionally for the European Union, there is the need to take into account the implications of its Kyoto Treaty targets for the way that we operate as industrialised, developed countries. Throughout the European Union, there are a number of major "pilot scale" projects (some might call them production units) investigating the production of fuel ethanol, as a petrol substitute, from a variety of renewable substrates such as starch, sugar beet and cellulose. The key countries involved are France, the Netherlands, Spain and Sweden. Most usually, the ethanol is converted into ETBE (ethyl tertiary butyl ether), an effective oxygenating biocarburant with many environmental benefits and which can be used as an additive to petrol, or as a replacement. In 1997 France sold domestically 155,000 tonnes of ethanol derived ETBE, equivalent to 10,000 ha cereals and 12,000 ha sugar beet. This volume will increase as further big plants, which are currently being planned, come on stream.

In France, the relationship between the selling price of the biocarburants and that of oil products is about 4:1. Essential to the success of these renewable fuel sources, therefore, is the support they are given by their National Governments through exemptions from excise duty and through direct subsidy. Such help is not available in the United Kingdom. Hence equivalent "pilot scale" projects have not developed here. The consequence is that our potential competitors on the Continent are driving ahead and gaining crucial production experience while we, in Britain, lag behind. Without the necessary "pilot scale" projects in Britain, to gain the necessary process expertise, it will be much more difficult to justify investment in these sorts of projects.

But recent technological developments both in the United States and also here, in the United Kingdom, mean that the cost of ethanol production will continue to decline. The engineering of micro-organisms that can convert whole biomass (rather than the fairly pure primary substrates, eg sugar, starch, etc as used currently) to ethanol will have a major impact. In addition, the use of this technology will provide a much needed route to give value both to agricultural wastes and, possibly, selected organic domestic wastes, which might otherwise require landfill. But the support of Government will undoubtedly be necessary in order to push these developments along.

British Sugar is interested in the possibilities that are opening for the United Kingdom to source more of its energy from renewable sources, while at the same time helping to meet its environmental commitments.

As a major crop processor in the United Kingdom we handle, through our nine factories, in excess of nine million tonnes of sugar beet (from some 170,000ha) in each processing season. The factories are strategically placed within the key arable belts of the United Kingdom, covering the east coast from York down to Ipswich, with two in the West Midlands in addition.

Each site is self contained and self sufficient, covering crop reception and sampling, a wide range of extraction, purification, concentration, crystallisation and drying unit processes. In addition, amongst the utilities which support the process are large scale effluent treatment, power generation (including export to the grid) and steam generation.

British Sugar has an infrastructure which links 9,000 growers with our factory sites and co-ordinates through our Agricultural Managers and Crop Advisors, the growing, storage and delivery of the crop on a "just in time basis". This same infrastructure could be used to co-ordinate the delivery of a range of other crops, including biomass in its widest sense.

British Sugar would welcome the opportunity to participate in the succeeding phases of this enquiry and would be prepared to present an illustration in more detail.

April 1999

Supplementary memorandum by British Sugar Technical Centre

May I offer my thanks to the sub-committee for giving Karl Carter and myself the opportunity to come to the House and make representation on the conversion of bio-mass to energy, and specifically bio-ethanol. We believe that the development of new technologies will have a significant impact on the production cost of this type of fuel. Similarly, the reduction of support will increase its opportunities although, as we pointed out, the gap between current oil price and the cost of bio-ethanol will remain a hindrance to the development of the latter.

At the hearing, we were asked to report back on the relative yields (fresh and dry weights) of sugar beet, fodder beet and sugar cane. I have attempted to use data from recognised sources and quote these where appropriate. The information follows:

	Yield (tonnes/ha)	*Fermentable Dry matter %*	*Dry matter Yield (tonnes/ha)*
Sugar Beet	55[1]	22.5[2]	12.4
Fodder Beet	80–100[3]	21.5[4]	17.2–21.5
Sugar Cane	60–90[1]	25[2]	15–22.5

1. F.O Licht's Sugar and Sweetener Yearbook 1997–98.
2. Sugar Technology—Vander Poel, Schiweck, Schwartz 1998.
3. NIAB Fodder beet recommended varieties list.
4. Brooms Barn Experimental Station.

Sugar cane yield is extremely variable and dependent on the country of origin. Equally, much higher figures have been quoted for fodder beet yields but the figures above are ones that we in the United Kingdom would be comfortable with.

I trust that this information is sufficient for your needs. If you require any further clarification, please do not hesitate to contact me.

Trevor Theobald
Development Manager

1 July 1999

Memorandum by the Chemical Industries Association

AGRICULTURAL CROPS AS FEED-STOCKS FOR THE CHEMICAL INDUSTRY

1. International Competitiveness

It is of fundamental importance in discussing the interface with agriculture to understand the exposure of the United Kingdom chemical industry to international competition. Around 70 per cent of the United Kingdom's chemical output is exported (with over half of this going to the rest of Western Europe) whilst 65 per cent of the United Kingdom chemicals market is supplied by imports, much of which, from outside the European Union as well as inside, already enters the United Kingdom duty-free through the Generalised

System of Preferences (GSP) scheme. The United Kingdom chemical industry has managed to maintain a strong trade surplus in recent years, outperforming other sectors in manufacturing.

Exposure of United Kingdom and European Union chemical companies to competition from the rapidly growing Asian economies in particular is very high, both at home and in third markets. Efforts to rationalise and re-structure remain a top priority in some parts of the industry in order to reduce over-capacity and meet competition.

Wider policy developments such as the current European Union Enlargement accession negotiations, anticipated WTO accession by China and Saudi Arabia and the forthcoming Millennium trade round will make international competition yet stronger.

All of the above underlines the importance to United Kingdom chemical companies of access to raw materials and energy at internationally competitive prices if they are to remain viable and continue their vital contribution to the United Kingdom economy and its balance of payments.

2. Agricultural Crops as Chemical Feed-Stocks

The majority of chemicals are currently generated from petroleum feed-stocks. However, in the past a wide variety of chemicals were derived from coal tar and agricultural crops. For example, over thirty years ago in India polyethylene was being produced from crops such as sugar. The actual process involved the fermentation of sugar molasses which resulted in the formation of alcohol. This was subsequently converted to ethylene which could be readily polymerized to generate the aforementioned polymer. Polyethylene could then be used in the manufacture of a wide variety of plastic articles such as washing-up bowls.

During the last thirty years, the conversion of crops into chemicals into finished products has continued to remain a viable possibility in a limited number of specific cases. An example would be the manufacture of highly specialised items such as certain medicines and pesticides as well as some high-tonnage commodities including soaps, solvents, citric acid and viscose. This is despite fierce competition and domination of the petrochemical industry in the supply of base chemicals for their eventual conversion into these types of products.

It is important to stress that the scope for utilising agricultural crops as chemical feed-stocks will depend upon a variety of techno-socio-economic factors. These include technological feasibility, economic viability and environmental acceptability. They are briefly discussed below.

Technological Feasibility

In recent years, the chemicals industry has been able to generate a number of chemicals based on raw materials such as sugar and starch. The use of these materials—once considered a preserve of the food industry—has occurred due to the burgeoning knowledge of enzyme chemistry and interest in sustainable technologies. As a result a number of basic chemicals, which were once only accessible through the conversion of petroleum-based products, can now be readily obtained from crops.

Furthermore, there have also been an increasing number of market-driven opportunities for making high-value products. An example would be in the development of special and proprietary starches as adhesives and starch-derived biodegradable polymers. These have already been realised. In the longer term, composite materials based upon thermoplastics (which have been developed from special starches) may also become a reality.

Concurrently, advances in biotechnology, genetic engineering, plant breeding and biochemistry, in which scientists can define specific characteristics (eg, fatty acid chain length, introduce useful functional groups and alter bond specificity) have already led to the production of new variety of crops. These in turn could be used to meet the increasing demands and needs for feed-stocks required by the chemical industry. It is noteworthy that work of this nature has already been undertaken with regard to linseed, sun flower and cuphea.

The Chemical Industries Association (CIA) believes that there is a considerable technological advantage and potential in the use of agricultural materials as a source for chemicals for use in applications such as pesticides, fungicides, resins, plastics, paints and printing inks. However, an active and focused R&D programme still needs to be pursued by both Government and industry in order to make this a viable possibility.

A key aspect of all this work is that it must be customer driven and directly related to the perceived or potential market opportunities. In turn, it is very likely that a number of products manufactured via this methodology would command a price premium. To promote a crop which farmers produce and simply want an outlet for, would preclude the formation of successful partnerships between the chemicals and agricultural industries.

Overall, there is a growing interest and acceptability within the industry to press for the recognition of chemicals from crops. For example, it is envisaged that in the future a large proportion of the chemicals industry output could eventually be obtained through the use of sustainable technologies including crops.

Economic Viability

The choice between oilfield and farmer's field will increasingly become one of cost. Given attractive and consistently foreseeable costings, the scope for agriculturally-produced chemical feedstocks is large. However, this has to be put into a realistic context. Real economies of the open world must dictate the situation and not market distortions and/or uncontrollable subsidies.

In the short to medium term, especially with the price of petroleum oil currently at low levels, there is little incentive for customers to switch from a petrochemical to a crop-based feedstock when the two alternative technological routes exist.

If it is to be internationally competitive, the United Kingdom chemical industry must have access to agriculturally produced materials at prices as close as possible to world prices. This means continued reform of the CAP and, in particular, it means avoiding the high administrative costs levied on chemical companies for operating the necessary CAP-related schemes.

Thanks partly to the refund system under the CAP for sugar and starch substrates, usage of both sugar and starch for chemical production in the European Union increased during the early nineties. However, although in 1998 the Commission reduced the abatement on per 100kg of sugar from 8.45 ECU to 6.45 ECU for a period of two years—a move welcomed by the CIA—the scheme still blunts the competitiveness of the United Kingdom chemical industry which remains unable to buy sugar at true world market prices.

In summary therefore, it is an essential part of "real" economics for chemical companies to have access, with the minimum of barriers, to agricultural materials from the world market. It would be a very harmful development if, in seeking to develop greater non-food agricultural production in Europe, the authorities were to make access to world markets for the relevant materials more difficult. This point of course also applies with particular strength to agricultural products more easily and economically produced in climates other than that of Western Europe.

Environmental Acceptability

As part of the increasing priority being given to sustainability, a number of official schemes and proposals are being considered. The Chemical Industries Association is playing an active part in the sustainable development debate and recognises the valuable role which renewable agricultural resources will play in the future. However, it is also extremely important that any proposals do not cause severe market distortions.

In assessing the scope for greater use of renewable resources, it is also essential that the entire environmental balance be considered, rather than just that part of the chain which offers the attractive features.

3. Conclusions

The chemical industry has already begun to recognise the importance of non-food crops as an alternative and sustainable source of chemicals. This can be readily demonstrated by the conversion of oilseed crops to industrial grade oil and its subsequent transformation into other chemicals.

The chemical industry has also begun to acknowledge the importance that these types of developments will play in transforming agriculture and enhancing United Kingdom competitiveness/technological prowess. However, there are a number of areas relating to policy issues which the CIA believes need to be properly addressed. These are outlined below:

(i) the need for a predictable and secure access to agricultural feed-stocks;

(ii) the continued reform of the CAP towards the availability of agricultural materials for the chemicals industry at world prices;

(iii) clarification in CAP and in GATT/WTO on how to treat crops providing both food and non-food products;

(iv) avoidance of market distortion for existing chemicals, and recognition of all environmental factors, especially when considering special schemes to promote renewable resources and issues concerning sustainability;

(v) increased investment in R&D with a particular emphasis on product and process innovation which are market-driven and offer high specificity and added-value;

(vi) increased dialogue and collaboration between Government and its agencies, industry, academe and the farming industry through initiatives such as Foresight, via pilot-scale demonstration projects and the LINK scheme; and

(vii) adequate protection of intellectual property in new biotechnological product and process inventions.

In summary, chemicals from crops offer an exciting possibility for the future success of the chemical industry. In turn, it is envisaged that this will contribute to an improvement in the overall quality of life in the United Kingdom.

Memorandum by DuPont (United Kingdom) Limited, Cereals Innovation Centre

Introduction

DuPont's main interest in crops for non-food users in the United Kingdom is in the extraction of valuable components from existing crops grown mainly for food. In addition, there is interest in plants developed using the techniques of genetic modification to produce feedstocks for production of existing and novel materials; currently, this work is carried out in the United States.

We believe that, although crops can be seen as alternative sources of feedstocks to produce existing materials, their greatest value will be in the generation of new and unique products.

Company Background

DuPont is a major global materials and life sciences company, headquartered in the United States of America (Wilmington, Delaware) and due to celebrate its bicentenary in 2002. Business sectors in which we operate are:

- agriculture and Nutrition;
- nylon;
- performance Coatings and Polymers (including engineering polymers and automotive finishes);
- pharmaceuticals;
- pigments and Chemicals (including titanium dioxide and fluorochemicals);
- polyester;
- speciality fibres (including Lycra®, Kelar® and Teflon® fibres);
- speciality polymers (including Teflon® and Corian®).

1998 sales were close to $25 billion worldwide, of which $988 million was generated in the United Kingdom ($6.3 billion in Europe as a whole).

UK Research: The Cereals Innovation Centre

The Cereals Innovation Centre, located in Cambridge, has been part of DuPont since January 1998. Before that, it was part of Dalgety plc, and has done research and development work on ingredients for the food and feed industries for many years. The principal areas for investigation have been cereals generally—with a strong focus on wheat and an increasing interest in wet fractionation—and functional (mainly vegetable) proteins.

While building up knowledge of the structure and function of crop components, primarily for the food chain, it was clear that much of this would also have applications in non-food markets. Our change of ownership at the beginning of 1998 gave new motivation for us to work in this direction, and accordingly a dedicated team was set up to work solely on non-food applications.

We are working now in several areas, all using materials derived from major cereal crops:

- composite materials, utilising cereal components as either the filler or binder;
- biomedical applications;
- applications in our existing crop protection businesses;
- biorefining as a means of producing raw materials and functional products (eg for paints, adhesives, oil industry, detergents, cosmetics and adsorbents).

External Research

While recognising the significant opportunities in these areas, we are not ourselves expert in all of them. We therefore have set up a programme of research (mainly at post-doctoral level), funding projects in centres of excellence at a number of United Kingdom universities.

Summary

DuPont has major existing businesses in non-food areas, including fibres, paints, composite materials and pharmaceuticals. In the United Kingdom, our extensive knowledge of the structure and function of cereal components (starch, non-starch polysaccharides and proteins) and other crop-derived materials puts us in a good position to exploit conventional crops in novel ways.

We believe that the greatest value in non-food markets will come from utilising some of the unique functionalities of crop (particularly cereal) components, rather than seeing them as sources of low-cost feedstocks.

European Union National Government Funding of Research

For comparison:

- in the United Kingdom, the BBSRC programme of research has a funding level of £4 million over five years, with half of this coming from industry. Even allowing for research into energy crops, we don't believe the total Government spend is more than £1 million annually;
- according to published figures, in 1997 the French organisation AGRICE had funded 150 projects over the previous three years at a total cost of £30 million: an annual spend approximately 10 times that of the United Kingdom;
- the German organisation FNR provided DM50 million of funding in 1997. This has increased to DM56 million in the current year: approximately £30 million;
- in Denmark, the Ministry of Agriculture is supporting six projects at a cost of DKr40 million over four years; an annual spend of about £1 million in a much smaller country.

All countries will have industrial research to be added to this, but it can be seen that the United Kingdom is at a severe disadvantage in terms of the amount of publicly-funded research in the area of non-food crops.

Martin Livermore

DuPont (United Kingdom) Ltd

June 1999

Memorandum by ETSU (part of AEA Technology Environment)

Preamble

ETSU is competent to comment on the questions raised as we have managed the DTI's Programme on Biomass for a number of years. We have also led the European Commission-wide Agriculture and Forestry Biomass Network project on behalf of the DGXVII ALTENER Programme, and have been major contributors to a number of other United Kingdom and international initiatives in this field.

Evidence

Question 1

1.1 Energy crops represent a significant potential in the United Kingdom as they will service a large and stable market that is likely to offer long term supply contracts. Furthermore, as the growth requirements for the woody energy crops are different to that for arable crops, they can be produced commercially on less productive land including the grassland currently used for dairy and livestock operations. This gives many farmers the opportunity to include energy crops within their farm enterprise to provide a guaranteed cash flow for the business.

1.2 The ideal energy crop requires minimum inputs to achieve high yields of a material that is amenable to harvest and produces a good fuel. This tends to favour perennial and not annual crops. The most studied energy crop in the United Kingdom is short rotation coppice (SRC) of willow and poplar. Because of the large number of varieties of poplar and willow that are available, this crop will be amenable to most of the soils and climates found in the United Kingdom. Similarly, there is potential to achieve significant increases in yields through crop breeding.

1.3 Grass crops grown for energy also have the potential to become significant in the United Kingdom. Some, like miscanthus, grow well in the drier warmer parts of the country and have the potential to produce higher yields than SRC where conditions are optimal. Other candidate grass species are grown from seed and thus offer lower cost establishment, but also lower yields. All of these offer the opportunity for a "portfolio" approach to energy crop production that reduces the risk of feedstock unavailability due to total crop failure.

1.4 The production of liquid biofuels has been studied at length on mainland Europe. Well-developed existing annual food crops like rape produce oil that can be easily esterified into the diesel substitute rape methyl ester (RME or biodiesel). This fuel can be used in unmodified diesel engines with little or no adverse effect on performance or wear. The problem with RME is that the energy balance is poor such that it produces only around twice as much energy as was used in its production. This can only ever result in poor economic

performance and the requirement for continued subsidy in the foreseeable future. It also means that by whatever measure used, more land will be required to produce energy from RME than from the "combustible" crops.

Question 2

2.1 Projections show that energy crops have the potential to become competitive with fossil fuels in the future. This does, however, require investment in crop improvements to increase yield and biological stability and the creation of a volume marker to drive down costs and to stimulate investment in appropriate mechanisation.

2.2 Crop yield improvements can be achieved through the application of normal breeding processes. This process can also be used to introduce genetic diversity into the crop and thus increase its biological stability. No genetic modifications will be needed in the foreseeable future, though the application of genetic mapping techniques will be needed to increase the speed and efficiency of breeding.

2.3 Consistency is less of a problem with energy crop production where it is the maximum mass of available material that is required. Most energy generation plants will process the fuel in some way before use further reducing inconsistency in the feedstock.

Question 3

3.1 Energy crops produce CO_2 when they are burnt, but the new crop growth absorbs an equivalent amount of CO_2 from the atmosphere making the whole process approximately neutral in carbon terms. When used to replace fossil fuels, net reductions in greenhouse gas emissions results.

3.2 Energy crops differ in their environmental impact during growth. All will introduce a change in the appearance in the landscape, and some like SRC offer enhanced biodiversity through their ability to attract insects and thus a range of other animals and birds. Energy grasses may be less attractive in this regard.

3.3 Life-Cycle Analysis of energy crops relative to fossil fuels should be possible.

Question 4

4.1 Energy crops have to compete with food crops on the grounds of return to the producer. Under current arrangements, the CAP provides a subsidy for most food crops and this automatically disadvantages energy crops.

Question 5

5.1 Until in volume production, the cost of establishing energy crops is high. This is exacerbated by the long delay between planting and first harvest. This can be as long as four years with some SRC crops. In the United Kingdom, this is offset to a degree by planting grants that are available through the Forestry Authority Woodland Grant Scheme. This has had to be "topped up" to £1,000/ha to attract growers to supply project ARBRE, which is the United Kingdom's first commercial SRC fuelled power station.

5.2 Each member of the European Union is likely to have its own view as to the most appropriate energy crop to grow given its climate, soils and current mix of energy supply. It is therefore important that each state is free to support whichever energy crop it finds most appropriate.

5.3 As well as ensuring a "level playing field" for producers of energy crops through the CAP, there is a need to ensure that there is an appropriate "market pull" for the crops produced. Thus within the European Union, emphasis must be given to developing these markets as part of the strategy designed to meet our CO_2 reduction targets.

5.4 The United Kingdom has one of the most advanced energy crop programmes in the European Union. In order to maximise the benefit from the public money spent to date, a concerted effort must now be made to stimulate the commercial uptake of energy crop supply and use.

June 1999

Memorandum by European Commission, Directorate—General XII, Science Research & Development

Thank you for your letter of the 19 February requesting a written submission to the House of Lords Science and Technology Committee non-food crops enquiry. I apologise for the delay in replying but I enclose for your information documentation to be offered as evidence of European Union activity in this sector over the past 10 years. This includes:

— four individual catalogues of European research contracts funded between 1988–1998 in the fields of non-food crop research: ECLAIR (European Collaborative Linkage of Agro-Industrial Research) programme final results, AIR (Agriculture and Agro-Industrial research) programme

non-food project catalogue, and the FAIR (Agriculture Agro-Industry Forestry Fisheries) programme Renewable Biomaterials and Bioenergy project catalogues;

— a publication entitled "Crops for Industry and Energy in Europe" which describes the different potential non-food crops which can be grown in Europe;

— a short booklet on "Renewable Biomaterials" which gives an overview of European Union research activities;

— flyers from three European networks sponsored by our programme dedicated respectively to, the dissemination of non-food research results NF-2000 (Non-Food 2000), an overview of European non-food crop production IENICA (An interactive network for industrial crops and their applications), and CTVO (the chemical and technical utilisation of vegetable oils);

— a "Working Document on non-food crops in the context of Agenda 2000" which explains in detail the European Union agricultural policy in this sector.

It is evident from the above that DGXII has been quite active in funding research in this sector since 1988 in three separate framework programmes. This is further illustrated in the following tables, which give the number of projects and the evolution of the research budget over the period in the bioenergy and renewable bioproduct sectors originating from non-food crops. In the tables, 2FP, 3FP, and 4FP respectively represent the second, third, and fourth research framework programmes of the Community.

BIOENERGY RESEARCH BUDGET EVOLUTION

(JOULE, THERMIE, AGRICULTURE, AND AGRO-INDUSTRY PROGRAMMES)

Programmes	*Duration*	*No. of Projects*	*EU spend*	*Total spend*
2FP	88-92	48	11	15
3FP	90-94	119	119	260
4FP	94-98	100	100	500
TOTALS	10 years	267	230	775

RENEWABLE BIOPRODUCTS RESEARCH BUDGET EVOLUTION

(AGRICULTURE AND AGRO-INDUSTRY PROGRAMMES)

Programmes	*Duration*	*No. of Projects*	*EU spend*	*Total spend*
2FP	88-92	15	25	47
3FP	90-94	46	78	135
4FP	94-98	80	74	122
TOTALS	10 years	141	177	304

Around 70 per cent of the projects funded deal with R&D the remainder are research networks and demonstration projects. Non-food demonstration projects were an innovative introduction in the third framework programme with important results generated in the feasibility of growing and exploiting a wide range of non-food crops as industrial feedstocks. The results of many of these projects were technically very positive but market exploitation has been hampered by existing regulations.

Furthermore, I have attempted to answer your individual questions in a brief manner but with reference to existing sources of information which give much greater detail.

1. The United Kingdom has substantial potential to develop a non-food sector. Already the first biomass gasification plant will open in Yorkshire this year. There are important incentives such as the Non Fossil Fuel Obligation and the research base is very active in the study of non-food crop agronomy, with important work being done in hemp, dye crops, miscanthus, and willow. While biodiesel is much less developed than in other Member States such as Germany and France, United Kingdom industrial and public research has nevertheless made significant progress in developing biogas installations, starch-based paints, natural dyes, fibre-based materials, and bioplastic and composite products. The United Kingdom ACTIN network is also an important national initiative for the focussing of information in this fledgling sector.

See Thermie demonstration projects in bioenergy catalogue, ACTIN website, FAIR contract catalogues.

2. The current non-food crop situation in Europe indicates that higher added value materials with specific applications are showing some success. With respect to bulk applications such as liquid fuels, solid fuels, or commodity chemicals, the regulatory bottlenecks are very strong and they will remain non-competitive while restictive practices under the current CAP are in place. The role of biotechnology is crucial as it can potentially increase the higher added value, reduce the production cost of bulk chemicals, and contribute towards a cleaner and more sustainable industry in the long term. Biotechnology in Europe however has its own set of regulatory and technical hurdles to overcome but as applied to improvements in non-food crops there is the advantage that consumer acceptance could be more tolerant.

See NF–2000 and IENICA website, FAIR catalogues, Working document on Non-Food crops.

3. The true environmental and ecological implication for the development of non-food crops has yet to be established. Many claims are made but generally accepted data and Europe-wide standards are missing. If a non-food crop sector were fully developed it would probably still involve intensive farming practices, however this has to be put in the perspective of sustained or increased rural employment. Moreover, Life-Cycle Analysis in its present format can only really claim that the growing of these crops and their utilisation is carbon neutral and that the end product is in general biodegradable. Even with the lack of standards and regulations industry is increasingly investigating the potential of non-food crops as renewable feedstocks, but in the final analysis it is the market which will decide if the current extra costs involved equate with any perceived environmental benefits.

4. The set-aside scheme, which arose as a result of the 1992 Common Agricultural Policy reform, is ostensibly a tool to control cereal prices. While restrictive in many areas it has at least given farmers in Europe the possibility to explore alternative crops. Until now it has almost exclusively been in oilseeds for the biodiesel market, and in flax for fibres used in the textile and building sectors. Their preference for rapeseed reflects their reluctance to take risks in this sector as it is a well understood crop which can be easily switched for cereal. The Agenda 2000 proposals in their current format could make existing non-food raw materials more competitive on the world stage as the price will be based upon the raw material and not the end-use as done previously. But bear in mind that there is no specific incentive for novel crops and the set-aside scheme is still in place until end of 2010. The proposal for a European Biofuel taxation directive has been suspended for the time being, nevertheless, a few member states do have their own individual agricultural and fiscal incentives for biofuels and non-food crops in place. The IENICA concerted action in the FAIR programme in its final report will deliver an overview of all the National regimes in place relating to non-food crops. This is a much needed analysis and should be available at the end of the year.

See "Working document on Non-Food crops". ACTIN website. IENICA website. Commission white paper on renewable energies.

5. An important aspect of the proposed Agenda 2000 reforms is the aim to make European agriculture more competitive on the world markets. Intrinsic to this is the issues of sustainability and global competitiveness, which have not always been a priority of the Common Agricultural Policy. Agenda 2000 proposes to rectify this by narrowing the gap between internal prices and world prices which will put at the disposal of food/non-food industries more competitive raw materials which are renewable and produced in a sustainable manner. Various support schemes have been in place over the past 10 years to promote the growing of new crops and the use of renewable raw materials in industry, but their lack of competitiveness can be blamed on aspects of cost, supply, and consistent quality. Furthermore, while no specific aid scheme is planned within Agenda 2000 for non-food crops, as mentioned previously, there is still a substantial bank of promising research and demonstration results developed since the late 1980's through European Union framework programmes. These programmes have been instrumental in demonstrating the potential for the various end products originating from renewable resources. Within the agricultural and agro-industry programmes they have used "the integrated chain" approach to forge links with between the farmers and producers and the processing and end product industries. The result of this has been that industry within these projects has now a better understanding of the specifications needed for the production and treatment of

biological materials for non-food uses. Some examples of product chains, which have been created include bioplastics, biofuels, fine chemicals, fibre materials, and fine chemicals. Research in the new fifth framework programme will continue to build upon the integrated chain approach with an added emphasis upon industrial participation, demonstration type activities, standardisation, and the socio-economic aspects of development within this sector. It will strive to deliver new market driven products of high quality, which are produced in a sustainable manner, renewable, environmentally neutral, and competitive in price.

See DGXII Research project catalogues.

In conclusion, I hope that the evidence offered here will be of some use to you in the preparation of your work and I would be grateful if you could keep me informed as to their eventual outcome. In the meantime I remain at your service should you require further information or extra copies of the information provided.

Ciaran Mangan
28 April 1999

WORKING DOCUMENT ON NON–FOOD CROPS IN THE CONTEXT OF AGENDA 2000

1. The Mandate

The CAP reform proposed by Agenda 2000 does not foresee a "non-food policy" as such. But by closing the gap between internal prices and world prices, it aims to put at the disposal of food/non-food industries more competitive raw materials.

Following the invitation of the Agriculture Council of 22–26 June 1998, the Commission undertook, "in the context of the Agenda 2000 reforms (...) to produce a report on the present state of the non-food and energy crop sectors and their future development, and if necessary to make appropriate proposals". The present working document is presented within this context.

2. Present State of Non-Food Sector in the European Union

2.1 *Land used to produce crops for non-food purposes*

The production of crops for non-food purposes (referred to in the present document as "non-food crops") has a long tradition. Flax and cotton fibres for the textile industry, starch for various industrial uses, various vegetable oils for production of biofuels, paint or other chemical products, and the cultivation of medical plants are some examples. Their importance has increased due to external factors, and in particular concern for renewable energies including bio-energy produced on agricultural land. Increasing surpluses of cereals were an additional reason to look for alternative market outlets for agricultural raw materials.

But it should be underlined that the most important source for bio-energy was—and still is—forest which for centuries has had a key role as a primary energy source. The contribution of forests to the energy supply varies regionally. In some Member States already 20 per cent of total energy supply stems from wood based energy sources. At present only 70 per cent of the annual wood increment is used in the European Union (of which some 15 per cent for enegy purposes). Links between agriculture and forestry have always existed and have been reinforced by afforestation programmes in the framework of the 1992 accompanying measures (Reg. EEC No. 2080/92). The cultivation of short rotation forest trees such as poplar and willow for the production of energy on agricultural and in particular on set-aside land represents a further opportunity.

After rising to 2.3 million ha in 1995–96, total non-food agricultural area in the EU-15 has returned to around two million ha in recent years, which represents about 1.5 per cent of the utilised agricultural area. At present, oilseeds grown on set aside land represent the main energy crop with nearly 400 thousands ha in 1997–98. Fibre crops (cotton, flax and hemp) are more important with 666 thousands ha, around one third of non-food areas. While cotton is exclusively grown in Greece and Spain, the main areas for flax fibre are in France and in Spain.

Maize, potatoes and wheat for non-food starch production together account for more than 600 thousands ha and are mainly produced in the large cereal producing regions of France, Germany, the Netherlands, Spain and the United Kingdom. The area of sugar beet for chemical use is much smaller, around thirty thousands ha. The production of medicinal plants covers only between 4,000 and 6,000 ha.

Table 1

AGRICULTURAL NON-FOOD PRODUCTION AREA IN THE EU (000 HA)

		EUR–12			EUR–15		
		1993–94	*1994–95*	*1995–96*	*1996–97*	*1997–98*	*1998–99(e)*
	Set-aside (1)	*4,640*	*5,995*	*6,411*	*5,567*	*3,978*	
	of which						
	compulsory				*3,836*	*2,052*	
	voluntary				*1,731*	*1,926*	
	non-food	242	707	1,041	660	393	415
	Cotton	383	423	473	502	510	508
N	Flax	52	89	104	132	133	166
O	Hemp	7	8	10	14	23	42
N	Linseed for oil	205	88	125	171	224	314
	Wheat	150	160	180	175	205	245
F	Maize	250	265	265	265	265	245
O	Potatoes	119	120	120	140	133	133
O	Sugar beet	26	24	33	31	31	32
D	**Total Non-Food**	**1,434**	**1,884**	**2,351**	**2,090**	**1,917**	**2,100**
% of non-food crops on set-aside		17%	38%	44%	32%	21%	20%

Sources: DGVI.

(1) Without 5 years set aside scheme.

2.2 *Energy production based on agricultural raw materials and wood*

As regards agricultural non-food uses, bioenergy is the sector which presently receives the broadest attention. Apart from direct combustion, which is of importance especially in Portugal and in the three new Member States, bioenergy has only a marginal share in the fuel mix. Extension of liquid biofuels is limited by high production costs and also by the availability of land which is in competition with other production uses. The energy balance in respect of liquid biofuels is generally positive[1], but the issue of positive environmental balance needs to be demonstrated on a case by case basis (ie, at a local level).

[1] Already in 1992 in the document "A new future for biomass" the Commission noted "il semblerait que la production de biomasse à des fins énergétiques ou industrielles débouche généralement sur un bilan énergétique positif. Ce bilan est plus ou moins positif selon l'utilisation et la transformation ultérieure des produits concernés."

In the White Paper on Renewable Sources of Energy (Com (97) 599 final), it stated that "biofuels have an overall positive energy balance, although this varies from crop to crop, and also depends on the crop replaced."

Table 2

ESTIMATED COSTS FOR BIOFUELS, OFF PROCESSING PLANT*, 1996

Liquid biofuels ECU/hl	*1hl of biofuel requires ...t raw material*	*price paid for raw material*	*cost transfo*	*value by prod*	*total production costs*	*competing fossil fuel price off refinery min*	*max*	*gap with foss fuel average*
Ethanol from sugarbeet	1	20	26	1.5	45	8	12	–35
Ethanol from wheat	0.285	22	38	13	47	8	12	–37
Diester	0.223	36	24	16	44	12	16	–30

Solid biofuels ECU/Gigajoule	*1hl of biofuel requires ...t raw material*	*price paid for raw material*	*cost transfo*	*value by prod*	*production costs*	*competing fossil fuel*	*gap with foss fuel average*
Wood chips from SRC					6	5.5	–0.4
Triticale					7	5.5	–1
Straw					4	5.5	2

Source: DG VI calculations, based on various sources.

* amounts under a situation with compulsory set-aside and tax exemption of biofuels.

Solid biofuels for direct combustion are often better placed and can be produced close to competitive prices, especially in rural areas and for on farm uses.

2.3 *Other uses of agricultural raw materials for non-food purposes*

There is a broad variety of technical uses for biomass, some of which seem to be very promising (lubricants, biodegradable plastics, plant protection products, various compounds for the chemical industry) and which will add high value to raw materials. These markets could offer a higher price for the raw material, however, demand is often limited. In markets with greater demand, for example that for starch-based chemical products, processors can substitute raw materials following price changes. This limits the perspectives for higher agricultural raw material prices, even where higher value added products are produced. In the medium term, the best market perspectives are for plants with a high content of specific compounds such as special acids, for production lines which offer a high value-added for as many compounds as possible of the whole plant, and for production lines which are based on cheaper agricultural by-products.

3. Agricultural Policy Supporting Non-Food Productions

Agricultural non-food policy is split into several market organisations and refund schemes, such as the starch refund scheme, the refund scheme for sugar in the chemical industry, the market organisations for cotton, flax and hemp. Moreover, a non-food set-aside scheme was introduced in the framework of the '92 CAP reform.

In addition, agricultural structural policy supports investments in the non-food sector. Important to this aim are horizontal measures of Objective 5a, regional measures of objectives 1 and 5b and the LEADER community initiative. Furthermore, two of the 1992 accompanying measures supported forest management and environmental friendly agricultural production.

Finally, the activities of Research and Development concerning renewable raw material production for destinations other than the human or animal consumption constitute an important objective for several European Union research programmes such as, for example, ALTENER, FAIR, JOULE, and THERMIE.

3.1 *Textile flax and hemp*

Producers of textile flax and hemp receive a per ha payment, which is fixed annually and which takes the world market price for seeds and for fibres into account (Council Regulation (EEC) No. 1308/70). Their cultivation has become relatively attractive especially since the reduction of cereals institutional prices. This and the adoption of less expensive harvesting methods can be seen as the most important reasons for the increase of textile flax production in Spain and in the United Kingdom in past years. In addition, it must be mentioned that the support scheme does not incorporate any ceiling or set-aside requirement.

3.2 *Cotton*

The main instrument to support cotton production is a system of "deficiency payment" covering the difference between the objective price set by the Council and world market price (Protocol No. 4 of the accession act of Greece and Council Regulation (EEC) No. 1553/95). This support scheme is limited by a maximum guaranteed quantity of 1.031 mio t divided between Greece and Spain.

3.3 *Starch production refund scheme*

The starch production refund scheme in its current form (Council Regulation (EEC) No. 1009/86) was introduced in 1986. The refund was conceived to bridge the gap between the higher European Union and the lower world market prices for the principal raw materials needed for starch production. The main objective of the scheme is thus to maintain the competitiveness of starch products. The refund is granted to the industrial end user, and not to the manufacturer of starch.

The Regulation defines the raw material as well as the end products which are eligible for a refund. Potatoes, wheat, maize and rice are eligible. In Finland and Sweden, oats and barley may also be used.

There is one single base refund for starch, which is based on maize as the raw material. Since the refund is for starch and not for the raw material a technical coefficient of 1.6 is applied (1.6 t of maize equal to 1 t of starch).

Following the reductions in institutional prices of the '92 reform, the refunds for starch diminished substantially from approximately 130 ECU/t before the reform to the current level of 61 ECU/t. With declining institutional prices, the refund system has lost much of its importance and this evolution will continue with Agenda 2000 proposal. In order to keep the balance between the different starch production lines, the mininum price for starch potatoes has also been adjusted downwards.

3.4 *Sugar for chemical industry (non-energy uses)*

The refund scheme for sugar used in the chemical industry covers only a small percentage of European Union sugar production (approx 1.5 per cent). Its aims are analogous to those associated with the starch scheme, ie to bridge the gap between the higher European Union and the lower world market price level. The refund scheme is based on the Council Regulation (EEC) 1010/86.

In principle, all sugar which is on the European Union market (ie A and B quota sugar) is eligible as a raw material. Eligible end products are restricted to the chemical sector (non-energy uses). It should be mentioned that there is some duplication of end product eligibility between the sugar and the starch schemes, so that differing levels of support may also have an influence on whether starch or sugar is chosen as raw material and a certain competition between the schemes on that level cannot be excluded.

Since the sugar refund scheme has not been affected by the 1992 CAP reform, European Union sugar prices remained well above world market levels and the refund has remained fairly constant at around 375 ECU per ton.

3.5 *Sugar beet for bio-ethanol*

Farmers can grow sugar beet to be used as a raw material for bio-ethanol production. Its price is freely negotiated between farmers and processors. Processors benefit from raw materials bought at non regulated price and much lower than the institutional prices of sugar beet devoted to sugar production. Therefore production of bio-ethanol has not been supported by any specific support scheme. Conversely, although sugar beet for bioenergy can be grown on set-aside, it is not eligible to the set-aside premium.

3.6 *The COP regime and the non-food set aside scheme*

The '92 reform established crop specific per hectare payments to compensate the reduction or abolition of institutional prices. These payments are based on historic regional yields, and paid in general on the condition that producers set aside a defined percentage of the land for which aid was requested.

Small producers, ie producers for which compensatory payments do not exceed an area corresponding to 92 t of cereals in their "yield region" may benefit from a simplified scheme under which they are exempted

from this obligation and get the cereal payment for all eligible COP areas (in this case the payment is non-crop specific). Under the general scheme farmers receive crop-specific payments including a set aside compensatory payment.

Table 3

LEVEL OF COMPENSATORY PAYMENT

Land use	*Institutional amount*	*Regionalisation*
Cereals	54.34 ECU/t	Multiplied by the regional reference yield
Oilseeds	433.5 ECU/ha*	Adjusted by the regional reference yield of cereals or oilseeds
Protein crops	78.49 ECU/t	Multiplied by the regional cereal reference yield
Linseed (non textile)	105.1 ECU/t	Multiplied by the regional cereal reference yield
Set-aside	68.83 ECU/t	Multiplied by the regional cereal reference yield

* Possible adjustment each marketing year to take into account the difference between the reference price and the observed price (with an 8 per cent franchise).

The reference rate for set-aside is currently 17.5 per cent but the applied set-aside rate, as shown in table 4, has been adapted each year taking into account the forecast market development.

Table 4

NON-FOOD PRODUCTION AREA ON SET-ASIDE IN THE EU (000 HA)

	EUR-12		*EUR-15*			
	1993–94	*1994–95*	*1995–96*	*1996–97*	*1997–98*	*1998–99(e)*
Oilseeds	226	676	997	660	393	415
—o.w. rapeseed	172	479	825	571	311	354
—o.w. sunflowerseed	32	138	144	89	82	61
—o.w. linseed	22	59	28	0	0	0
Cereals	9	16	18	*18*	*18*	*18*
Sugar beet	1	6	6	*12*	*12*	*12*
Short rotation	0	0	14	18	18	19
Medicine plants	4	6	6	*6*	*6*	*6*
Others	2	3	4	*4*	*4*	*4*
Set-aside rate	15%	15%	12%	10%	5%	5%
Total	242	707	1045	718	451	474
% Oilseeds	94%	96%	95%	92%	87%	88%

Source: DGVI.

NB: Italic figures are DGVI estimations.

Furthermore farmers are allowed flexibility in the management of their set aside obligation:

— they may use the set-aside land to grow non-food crops, ie crops whose final destination is non-food/non-feed use, and still receive the corresponding compensatory payments (except for sugar beet). Oilseeds are the main raw materials concerned by this scheme (for chemical uses and bio-fuels). The Blair House Agreement of 1992 requires that the quantity of oilseed by-products produced on set-aside land and destined for feed/food use does not exceed one million tonnes of soyameal equivalent;

— in the regions concerned, producers may also take part in long-term set-aside of agricultural land for environmental reasons (Council Regulation (EEC) No. 2078/92) or the afforestation scheme (Council Regulation (EEC) No. 2080/92). They then receive payments *according to the conditions laid down in these regulations which,* however, *cannot be higher than the normal set-aside compensation.*

In order to ensure that raw materials grown on set-aside land are really processed into non-food end products, the area sown and the yields obtained have to be monitored and controlled. This is particularly important since most raw materials eligible for non-food set a-side can be processed into food/feed and/or non-food end products. Regulation (EC) No. 1586/97 stipulates that at least 51 per cent of the economic value of all end products must be non-food products. The remainder may be used in the food/feed sector.

The eligibility of raw materials is specified in two positive lists. The first list covers raw materials which have potential for use in food/feed markets. Rapeseed and sunflower are by far the most important ones. Sugar beet may be planted on set-aside land but the land does not benefit from a set-aside premium. The second list contains raw materials which can in no way be used for food or feed (for example short rotation trees). The eligible end products are specified in a third list.

For all products on the first list of raw materials, the European Union Regulations foresee a rigorous control mechanism. In particular, producers and first buyers have to sign contracts before sowing, approved by the national authorities. Apart from control, the contract system ensures that supply cannot exceed demand, which would lead to speculation and pressure on non-food markets.

4. Agenda 2000 and Non-Food Crops

The strategy paper on enlargement presented by the Commission at the Madrid summit in 1995 put emphasis, as general goals for the future orientation of the CAP, on making *EU agriculture more competitive,* on achieving an integated policy for *rural areas* and on simplifying the existing mechanisms and procedures.

This strategy was confirmed in the Agenda 2000 communication of July 1997 and the related legislative proposals for March 1998. based on the outcome of the 1992 reform and on the long-term prospects for agricultural markets, the Commission laid down a number of objectives to be met by a further reformed agricultural policy. Among other goals, the Commission *reaffirmed* the need to improve the *competitiveness of European agriculture* while allowing for *on-and off-farm diversification.* Rural development policy becomes the second pillar of the CAP. An integated policy of this type will strengthen the sustainable development of agriculture and rural areas, meeting environmental concerns.

Non-food production and non-food policy should therefore be regarded within this general framework and it should be asked in which ways non-food production might contribute to these objectives. In the July 1997 document the production of raw materials for non-food uses was referred to as a possible "new opportunity" for agriculture and forestry, and a contribution to diversification.

Within Agenda 2000, there is no specific proposal for a non-food policy as such. Nevertheless, several proposals entail provisions relating to non-food. They are briefly mentioned below and will be further analysed in subsequent sections:

- the proposal on support for producers of arable crops. The reference rate for compulsory set-aside is fixed at 0 per cent. Nevertheless, the cultivation of non-food crops under the voluntary set-aside scheme will still remain possible. Member States shall apply appropriate environmental measures which correspond to the specific situation of the land set aside;
- the proposal on rural development. The development of non-food production falls within the scope of an integrated rural development strategy. Therefore non-food is eligible for support within this framework, in particular;
- when establishing their development plans, national competent authorities can decide to put emphasis on this sector;
- the "accompanying measures" of the 1992 reform are to be fully integrated in the general rural development policy. Two of them could be helpful for non-food: the afforestation and the agri-environmental measures. The eligibility of environmental friendly non-food production under the agri-environmental scheme is widened in Agenda 2000. Combined with increased importance and resources for this scheme, this offers further possibility for non-food provided that the schemes go beyond Good Agriculture Practice and result in environmental benefits well suited to local conditions. Afforestation measures are now part of a comprehensive support scheme in favour of forestry.

The Common Market Organisation for Wine, the reform of which is part of the Agenda 2000, also contains provisions on non-food uses of wine alcohol. Presently, the alcohol produced through compulsory distillation has to be disposed of outside the potable alcohol sector. As the market for wine is expected to remain globally balanced, it is proposed to suppress the compulsory distillation of table wines and, instead, to introduce a crisis distillation focused on regions or wines for which there is a surplus. As a result the disposal of wine alcohol outside the potable alcohol sector would be limited, coming mainly from the distillation of by-products (which is maintained).

As far as fibre crops are concerned, amendments have recently been adopted for hemp, and changes are under examination for cotton as requested by the Agriculture Council of June 1998. In the framework of the existing market organisation for cotton, there is little scope for increasing production, due above all to the limits which have been put on the support spent on this sector.

Following the request of the Agricultural Council of June 1998, the present report focuses on the prospects for non-food and energy crop sectors in the context of Agenda 2000 proposals. Crops grown under the set-aside scheme are mainly used for energy purposes. Given this link with set-aside, a first part of the analysis deals with the effects of the proposals in the arable crops sector. In the second part the impact of non-food crops on rural development and on the environment is examined.

4.1 *Effect of the proposals for arable crops on the relative competitiveness of food and non-food outlets*

Two main elements of the proposals for arable crops concern non-food crops:

— a 20 per cent cut in support prices for cereals and a non-crop specific direct aid of 66 ECU/t for cereals, oilseeds and for voluntary set-aside. This aid is converted into a per hectare payment on the basis of historical regional yields for cereals;

— a reference rate for compulsory set-aside fixed at 0 per cent.

These elements have an effect on the relative profitability of food and non-food crops, and between non-food crops. As rapeseed used in the biodiesel sector covers around half of the non-food area under the set-aside scheme, special emphasis will be placed on this crop, as a key energy crop.

4.1.1 *Non-crop specific aid and cut in prices for cereals*

Changes in the level of direct aid for arable crops and for the set-aside payment are indicated in table 5:

Table 5

LEVEL OF DIRECT PAYMENTS UNDER AGENDA 2000

Land use	*Present amount ECU/t*	*Agenda 2000 amount ECU/t*	*Regionalisation ECU/ha*
Set-aside	68.83		
Cereals	54.34	66	Multiplied by the regional cereal reference yield
Oilseeds	94.24		
Linseed (non textile)	105.1		
Protein crops	78.49	72.5	Multiplied by the regional cereal reference yield

Under Agenda 2000, the level of direct payment is the same for cereals, oilseeds and for set-aside. Given that the cultivation of non-food crops under the set-aside scheme remains possible, food and non-food crops are put on an equal footing. The slight reduction of set-aside payments under Agenda 2000 will not, as such, have any effect. The determinant factor is the relative profit margin.

A non-crop specific aid implies that the relative profitability of different crops is given by the respective gaps between market prices and production costs. However, agronomic constraints also play an important role, in particular for the rotation between oilseeds and cereals.

Under Agenda 2000, the decrease in direct aid for oilseeds is linked to the price cut for cereals. Fears have been expressed as to the possible negative impact on oilseeds production in the European Union. Various simulations have shown that, for an oilseeds price between 220 and 230 ECU/t, these readjustments would not significantly modify the relative profitability of cereals against oilseeds. Thus, on the whole, the European Union production of oilseeds should not substantially change. But, it is admitted that, in some specific regions, the equalisation of the premium for oilseeds, cereals and set aside could modify the relative profitability of these options.

In the biofuel sector, the price cut for wheat could increase its attractiveness to be used for ethanol production compared to oilseeds for diester production. Presently, as previously shown in table 2, the gap between the production costs of biofuel and competing mineral fuel is much wider for ethanol than for diester. For wheat-based ethanol, this is partly due to the higher processing costs, which will not be fully offset by lower prices of wheat under Agenda 2000. In other words, ethanol would still be less competitive than diester.

In recent years, total production costs of diester have fallen, despite a progressive increase in the price paid for rapeseed. This decreasing trend in diester production costs is expected to continue. In the medium term, technical progress should lead to cost reductions throughout the production chain of diester. These reductions could be more significant for diester than for ethanol.

4.1.2 *Compulsory set-aside*

(a) Compulsory set-aside above 0 per cent

As long as the rate of compulsory set-aside is above 0 per cent, for example 5 or 10 per cent, little will change as compared to the present situation. Producers subject to the set-aside obligation will have in principle a choice between two possibilities: setting land aside or growing crops for non-food uses on it. A key factor determining their choice will be the income they expect from each of the two alternatives.

In the case of set-aside the income is given by the difference between the regional set-aside payment per hectare and the cost of maintaining the land set aside.

In the case of crop production for non-food uses they will receive in addition to the set-aside payment a market revenue for the crop cultivated. On the other side they have the costs of producing the crop. Since land and in general also machinery are available, these costs will normally be the variable costs of production.

Market revenue will depend on the quantities produced per hectare and on the price that can be obtained from the crop when it is sold for non-food uses.

In the case of a number of niche markets, in particular for specific uses in the chemical and pharmaceutical industry, prices are in general high enough to make the production of crops for these uses attractive without any additional incentive. Farmers who are subject to the set-aside obligation and who have the possibility to grow crops under contract for these niche markets can therefore normally be expected to do so. However, although it is growing, the absorption capacity of these niche markets still remains quite limited.

In the case of liquid biofuels, the absorption capacity of the market is much bigger, but the prices processors are prepared to pay to farmers are much lower. In fact, these prices are based on the price of competing mineral fuels and would not be attractive without any additional support measures. Partial or total tax exemption of liquid biofuels is a measure which is often applied in this context. It allows processors to pay a sufficiently high price to farmers to make this option attractive on compulsory set-aside.

(b) Compulsory set-aside at 0 per cent

Although compulsory set-aside rates above 0 per cent are still possible under Agenda 2000, they are intended to be more an exception than the general rule. If longer-term market developments take place as expected, the compulsory set-aside rate should come down to 0 per cent.

In such a scenario, farmers no longer have to choose between compulsory set aside and crop production for non-food uses on it. Their main choice is now between crop production for food and feed uses or crop production for non-food uses. In addition, they still have the possibility to keep (marginal) land they do not want to cultivate under voluntary set-aside.

In cases where the same crop can be used for food and non-food uses the costs of production will in principle be the same. Farmers will grow the crop and sell it at the best price. They will have no interest to supply the non-food sector if the price paid in this sector is lower than in the food sector.

To illustrate the point, take the example of rapeseed. With a compulsory set-aside rate fixed at 0 per cent, farmers will have no more reason to grow and sell rapeseed for diester production at lower prices. They will make their production decisions according to prices expected on the dominant market, ie food and feed market. When selling rapeseed to the crusher, the farmer will not accept a lower price than the one he expects for the food and feed market.

The question is how the processor—in our example the producer of diester—will be able to pay such a price. This will depend on the price he can get for his product—diester—on the fuel market as well as on his own production costs.

As far as the price on the fuel market is concerned, tax exemption or detaxation of biofuels remains a key issue for the foreseeable future, except where there would be a general obligation to add a certain percentage of biofuels to mineral fuels (eg up to 3 per cent).

As far as the processing costs are concerned, the experience with diester seems to indicate that, once a stage of industrial production is reached, costs tend to fall over time due to technical progress. In the case of diester this trend of decreasing production costs is expected to continue also in the future. But for the years to come it will by far not be sufficient to make the non-food use of rapeseed a competitive alternative to its food and feed uses. The European Biodiesel Board (EBB) has even questioned its very survival if the present proposals under Agenda 2000 remain unchanged. In particular, the EBB has asked for a "scheme whereby biodiesel producers would purchase raw materials at open market conditions and receive a compensation to offset the additional production costs"[2].

Similar concerns have been raised by COPA/COGECA.

4.1.3 *Concluding remarks on liquid biofuels*

In Member States producing biofuels, these benefit from tax exemption. Together with the opportunity provided for by compulsory set-aside, this explains the existence of production as it provides for a certain margin of profit.

More than the opportunity provided for by the compulsory set-aside scheme, tax exemption is a key condition for the relative profitability of liquid biofuels. In the absence of compulsory set-aside, this condition becomes even more important.

[2] Letter of EBB sent to the Commission (19 February 1995).

Tax exemption is an essential way of promoting biofuels. The advantages of biofuels go well beyond the agricultural sector. It is a matter of public interest for which global policy instruments should be considered. Fiscal instruments are one amongst them; other actions could be considered on the demand side, like specifications for the quality of fuels. The Commission has already tabled a series of proposals along these lines.

The Political Context of Renewable Energy

Increasing emissions of "man made" greenhouse gases and their possible impact on the world climate is a reason for growing concern, which has already led to a number of political commitments and considerations with the aim to reduce the overall emissions of greenhouse gases and especially of CO_2. In the context of the Rio Conference and the Kyoto Protocol the European Union has committed itself to reduce CO_2 emissions by the year 2000 by 8.1 per cent in relation to the level of 1990.

The White book on "Energy Policy for the European Union" of 1996 states that, despite increasing energy efficiency, energy consumption in the European Union and dependency on imported energy will increase in the next decades. Nevertheless, world oil reserves are not expected to be exhausted, with the result that energy prices would remain relatively stable in real terms.

If these assumptions on the development of energy demand have to be brought in line with the commitments made concerning CO_2 emissions, bioenergy needs to play a larger role in the fuel mix. The utilisation of biomass releases only as much CO_2 to the atmosphere as has been bound by the plants while growing. This is why, apart from the energy which is used for processing and transport, the sustainable utilisation of biomass represents a CO_2 neutral option for the production of energy and other products. The use of biofuels offers other environmental benefits, for example in improving the lubricating characteristics of low-sulphur diesel fuels.

The White Paper for Renewable Energy resources adopted in November 1997 sets an indicative target of doubling from 6 per cent to 12 per cent the share of renewable energy resources in the total energy consumption of the EU by 2010. Indicative contributions from each renewable energy source have been estimated. "According to the particular scenario outlined, the main contribution (. . .) could come from the biomass, tripling the current level of this source." Of the 90 Mtoe[3] additional energy expected to be obtained from biomass, "the contribution for bioenergy from crops is estimated at 45 Mtoe. Of this, 18 Mtoe could be in the form of liquid biofuels (including however liquid biofuels from non-energy crops such as wood residues, used vegetable oils, or biogas used as motor fuel) and 27 Mtoe as biomass for heat and/or power, under one particular scenario." Moreover, it is estimated that 30 Mtoe can be obtained from wood and agricultural residues and 15 Mtoe from biogas. In 1995 non-renewable energy production accounted for more than 90 per cent of greenhouse emissions [4].

Beyond environmental benefits, a range of other factors argue for greater exploitation of bio-energy resources. They include the reduction of import dependency, the potential contribution to employment and regional development, the creation of new niche markets in renewable technologies and the wide public support they command. However, capacity to meet demand for renewable energy is currently constrained by input and transformation costs in comparison with non-renewable resources.

Market prices for non-renewable fuels do not necessarily reflect their full social cost, particularly in relation to environmental externalities. Since the beginning of the 1990s, the European Union and the Member States have initiated a number of fiscal and regulatory proposals in order to support a sustainable energy policy, which respects the environmental targets and the international commitments of the European Union. Bio-energies are directly or indirectly affected by these measures.

These include the Council Directive restructuring the Community Framework for Taxation of Energy Products[5]. This proposal enlarges the scope of the Community minimum rate system beyond mineral oils to cover all energy products use as heating or motor fuel or for electricity generation. The proposal provides Member States with a number of options to pursue more ambitious environmental policies such as emissions and energy taxes, excise duties and exemptions. There are specific provisions for biofuels. Analysis suggests that the proposal will result in a reduction in CO_2 emissions between 0.5–1.5 per cent from the year 2005 compared to the business as usual scenario[6]. Minimum standards or fuel specifications are also likely to encourage the use of biofuels.

The reduction of the costs of renewable energies will also depend on the development and dissemination of new technologies for production, transformation and energy generation. Renewable energy technologies are likely to have longer payback periods than conventional energy technologies. This may be compounded by a lack of certainty about commercial viability and risk. A range of initiatives at the Community level under the ALTENER, JOULE, THERMIE and the Community's RTD framework programmes have been undertaken to promote research and development in field of renewable energy.

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[3] Mtoe = Million tonnes of oil equivalent.

[4] Second communication from the European Community under the UN Framework Convention on Climate change.

[5] COM (97) 30 final.

[6] Second communication from the European Community under the UN Framework Convention on Climate change.

Estimates suggest that to meet the 12 per cent renewable energy target, a total investment of ECU 165 billion will need to be made in the sector between 1997 and 2010 (ECU 84 billion in biomass)[7]. The annual energy technologies market for renewables could reach ECU 40 billion by 2020 from the current ECU 5 billion[8]. The scale of investment by the private sector will depend largely on the development and dissemination of appropriate technologies and processes and the certainty of demand for energy from renewable sources.

Instruments in the Agricultural Supply Side Cannot Ensure, on Their Own, the Development of Biofuels

The possibility of growing non-food crops under the compulsory set-aside scheme was an opportunity for the non-food sector, but is not an appropriate instrument to promote non-food production. The sustainable development of non-food cannot be based on a set-aside rate which varies from year to year according to the market situation for food commodities. One has to recall that compulsory set-aside is a supply-management instrument conceived to deal with cereal surplus situations. Considering the improvement in the market situation following the 1992 reform as well as the prospects of increased demand for grains, it is proposed to fix the rate of set-aside at 0 per cent and to cut the price of cereals in order to reduce the gap with world prices. Prices for oilseeds are already at world market levels. Where there is a demand for non-food—even if initiated by public action in the case of biofuels—the corresoponding raw agricultural material will be supplied by farmers.

An alternative would be the introduction of a permanent specific subsidy for non-food crops on set-asisde land, to reduce the price of raw materialis for the processing industry. This is not an appropriate measure. A permanent aid for non-food crops, higher than the non-crop specific aid, could question the underlying logic of Agenda 2000. It would appear difficult to justify a permanent additional direct aid for non-food crops on set-aside land in order to stimulate the cultivation of oilseeds, while in the European Union there is a deficit for food-fed oilseeds. Finally, an additional direct aid for non-food crops grown on set-aside land, including oilseeds, would bring the European Commission back under Blair House constraint.

However, some Member States, taking into account the difficulties of existing industry, favour the possible implementation of a degressive support scheme.

It should be recalled that there are many other outlets than bio-energy for non-food crops, for example:

— the production of lubricants based on plant oils. Forty per cent of the oilseeds grown on set-aside land are used in the sector of oleo-chemistry. These outlets are more competitive than biofuels and there is a higher profitability;

— specific products for the chemical and pharmaceutical industry, which are currently less important in quantitative terms, but may develop positively and increase the diversification of agricultural production, which is also an aspect of competitiveness. For these specific products, for which there is no competing food use and value-added niche markets, a relatively high price could be paid to farmers.

Their quality of being more easily biodegradable is a major argument in favour of these products and more constraining environmental legislation may increase their market share.

4.1.4 *Opportunities for non-food crops under the voluntary set-aside scheme*

The production of non-food crops under voluntary set-aside, that is to say with the non-crop specific direct aid of 66 ECU/t still offers an apportunity for a wide range of non-food crops. The voluntary set-aside scheme is clearly of interest for crops other than cereals, oilseeds and protein crops, as they would not be eligible for the aid outside of this scheme. This applies for instance to some medicinal plants.

Moreover, the voluntary set-aside scheme could constitute an appropriate framework for multiannual crops devoted to biomass production. The Agenda 2000 proposal already offers the possibility to grant the voluntary set-aside payment on a multiannual basis for a period of up to five years. Furthermore, the proposal of March 1998 could be amended to be in line with the possibility already introduced in the arable crops regime in June 1998 for multiannual crops devoted to biomass production. Here Member States are authorised to grant national aids up to 50 per cent of the establishment costs for these crops. If adopted, these conditions are appropriate for short rotation coppices.

In addition, the proposal for rural development foresees a similar possibility for wood production for a duration up to 20 years. Nevertheless as stated in the recent *Forestry strategy for the European Union* (COM (98) 649) "although short rotation for energy production can contribute to a slowing of the rise in atmospheric carbon dioxide concentrations, care should be taken to ensure that this does not have adverse affects on the environment".

[7] COM (97) 599 final (White Paper on Renewable Energies).

[8] Second communication from the European Community under the UN Framework Convention on Climate change.

5. Rural Development and Environment

The production of non-food raw materials can have an impact on the development of rural areas, especially if investments in the upstream and downstream sector can be achieved, if new jobs can be provided and regional economic circuits can be strengthened.

Up to now, apart from textile fibre production (cotton, flax and hemp), non-food production has been mainly a domain of the big cereal and oilseed producing regions in the North Western parts of the European Union. The production of non-food raw materials in these regions represents generally just an additional option among others. Opportunities for the Mediterranean regions or for less favoured areas have been rather limited.

Interesting developments with a positive impact on rural economies as a whole can be expected first of all with the production, processing and marketing of high value added niche products, like medicinal or aromatic plants or with multi-purpose plants, which offer interesting market outlets for all main- and by-products and especially if processing capacities can be established within the region of production.

In the energy sector, which has the largest market potential, expectations are limited. There is a major difference between solid and liquid biofuels as far as their utilisation is concerned and they also address different markets.

Solid fuels use the whole energy content of the plant. They can mainly be used for the production of heating energy directly on the farm or for the energy supply of rural communities and industries. Due to the fact that the gap in profitability between solid biofuels and the competing fossil energies is relatively small and the energy and CO_2 balance is favourable, this option may become increasingly interesting, especially in regions with a high supply of residual biomass, such as straw, or in areas with a high forest coverage. The production of solid fuels in short rotation plantations, which (except in specific cases) up to now has not gone beyond the level of research and demonstration projects, is subject to higher investment costs, but may develop positively if the economic and technical aspects can be improved.

Liquid biofuels use only part of the energy which is contained in the plant and need further processing before utilisation. Their main employment is in the motor fuel market. Under present market conditions liquid biofuels need high levels of public support. Their energy balance as well as the CO_2 balance is still positive but less attractive than solid biofuels. If used as oxygen additives in motor fuels, biofuels can reduce the CO_2 emissions of motor vehicles and have a positive impact on air quality, especially in regions suffering from a high level of air pollution.

Another important issue is the development and cultivation of environmentally friendly low input crops, like the oil producing plant "camelina sativa", or starch containing plants such as "quinoa", requiring only low applications of fertilisers and pesticides. In this context, it has to be taken into account that the development of new agricultural production for traditional market outlets will displace—at least to some extent—traditional raw materials, so that the full potential of the positive impact would not be reached.

Especially in environmentally sensitive areas, these opportunities may gain momentum. For the future development of new non-food production lines further investigations on the market side will be necessary, and improvement of the profitability of the production lines will be needed to increase their positive impact on rural development.

Moreover, the impact of production and processing of non-food in rural areas will be first of all in the downstream activities. The direct impact of cultivation on agricultural employment is limited, since agricultural area will not increase and labour intensity for most of the non-food raw materials is not higher than for other arable crops. If processing facilities for niche markets can be established, this may have a positive impact on local employment. But existing studies on the impact of non-food on rural employment are not significant enough to quantify the impact of different non-food options on this development.

Concerning environment the impact of biomass production does not differ from that of agricultural production in general. Intensive crops like sugar beet or potatoes can be more critical, especially if crop rotation cycles are short. The processing of agricultural raw materials, especially potato starch and sugar, can have some negative effects on environment. Utilisation and disposal of products based on agricultural raw materials, for example biodegradable plastics and lubricants, generally offer advantages over competing products, which are often based on petro-chemicals. The CO_2 reduction potential and the energy yield for liquid biofuels are relatively low, which diminishes their environmental benefits. From that point of view, the direct combustion of biomass would be the preferred option. The overall environmental balance has to take into account all these contrasted impacts at their respective levels. Envoragement of non-food crops does not necessarily lead to real environmental improvements.

6. Conclusions for a Debate

Within Agenda 2000, there is no specific proposal for a non-food policy as such. Nevertheless, several proposals entail provisions relating to non-food:

— *The proposal on support for producers of arable crops.* The reference rate for compulsory set-aside is fixed at 0 per cent. Nevertheless, the growing of non-food crops under the voluntary set-aside

scheme will still remain possible. Member States shall apply appropriate environmental measures which correspond to the specific situation of the land set aside.

— *The proposal on rural development.* The development of non-food production falls within the scope of an integrated rural development strategy. Therefore non-food is eligible for support within this framework, in particular:

  — when establishing their development plans, national competent authorities can decide to put emphasis on this sector, given the important possibilities offered by the rural development proposal to Member States in defining their priorities themselves;

  — the "accompanying measures" of the 1992 reform are to be fully integrated in the general rural development policy. Two of them could be helpful for non-food crops: the afforestation and the agri-environmental measures, provided they respect in full the environmental requirements within these measures.

These Agenda 2000 proposals provide various types of opportunities and support for non-food crops:

— as far as crops allowed on set aside are concerned, the most promising outlook seems to be for specific products for the pharmaceutical and chemical industries, including the production of lubricants based on plant oils;

— for environmentally friendly non-food crops, support can be granted under agri-environmental measures. As already stated in the White Paper "Renewable sources of energy", agri-environmental schemes "where energy crops are produced using reduced water supply, low inputs, by organic methods or harvested in the way to promote biodiversity etc could attract a premium. The Commission could envisage (...) to support energy crops respecting the fact that priorities for programmes would continue to be set by regional needs and potentials.";

— the voluntary set-aside scheme could constitute an appropriate framework for multiannual crops devoted to biomass production. Special provisions are already proposed in this respect: national aid is authorised and the set aside payment can be granted on a multiannual basis for 5 years. The possible extension of this period is an issue which has been raised by several Member States, in particular to take account of the long pay-back period for investments in this sector and the role of long term contracts in ensuring the supply of raw materials;.

— moreover, the forestry measures of the rural development proposal foresee a support for afforestation of agricultural land up to a maximum of 20 years, which can also be granted, under certain conditions related to the protection of environment, to short rotation coppices.

As far as energy crops are concerned, the solid biofuel option may become increasingly attractive, especially in regions with a high supply of residual biomass, such as straw, or in areas with a high forest coverage.

For liquid biofuels, the whole context is different. If the compulsory set aside is fixed at 0 per cent, farmers will not accept any discrimination in prices or administrative requirements based on the final uses of products.

Some important questions have to be answered as regards liquid biofuels. These concern their potential advantages and the most efficient policy instruments to deal with them. The advantages offered by biofuels have to be considered at levels well beyond the agricultural sector, it is a matter of public interest, for which global economic policy instruments are to be applied.

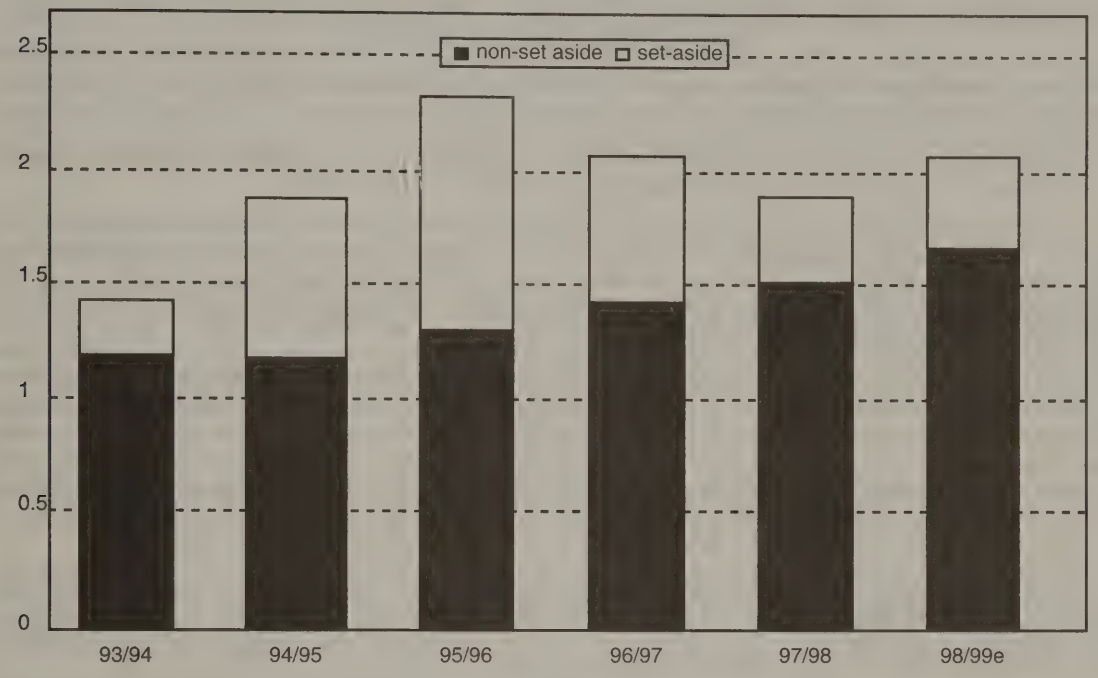
The sustainable development of biofuels cannot be ensured solely by instruments on the agricultural supply side. Fiscal instruments are one amongst them and tax exemption has proven to be an effective approach. Other actions could be considered on the demand side, such as specifications for the quality of fuels (low-sulphur content, oxygen components). The Commission has already tabled some proposals along these lines.

Taxation and legal obligations linked to international commitments of the Member States and the Union are key issues. Already now, in Member States producing biofuels, these benefit from tax exemption, and this explains the existence of production.

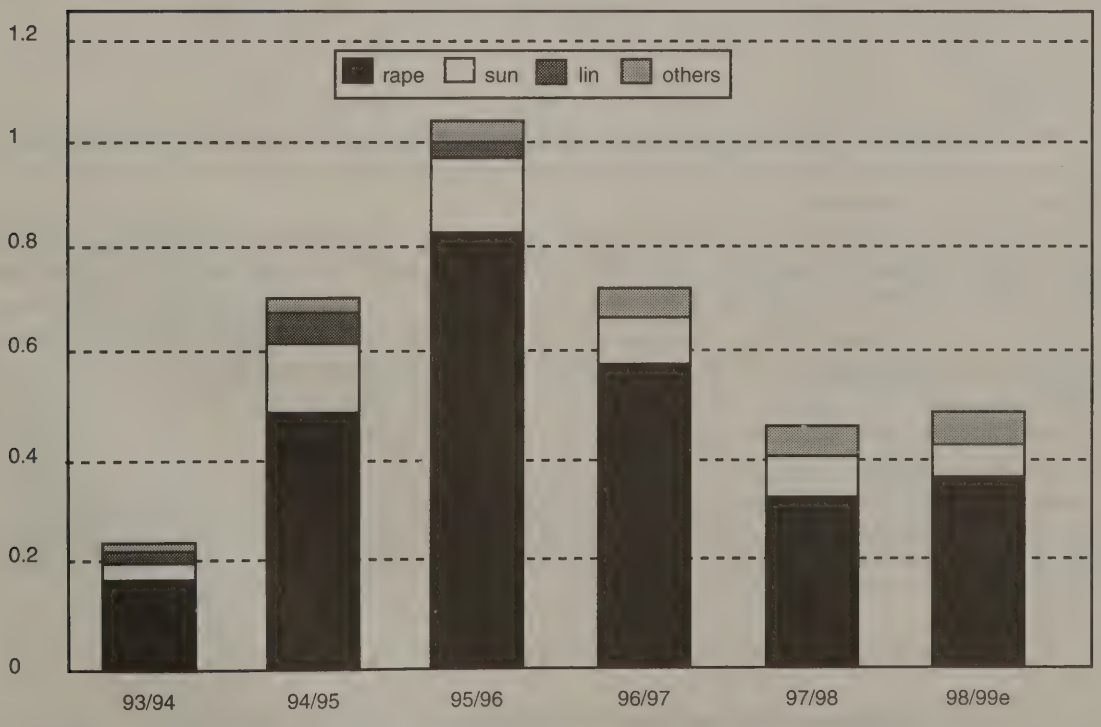
Conversely, a supplementary direct aid for non-food crops grown on set aside land, including oilseeds, would bring the European Commission back under Blair House constraint. Furthermore, it could question the overall thinking which has guided the Agenda 2000 proposals for agriculture. However, some Member States, taking into account the difficulties of existing industry, favour the possible implementation of a degressive support scheme. The Agenda 2000 proposals represent a significant move to a major decoupling of the support to arable crops. Farmers will receive an identical payment whether they produce cereals, oilseeds or a whole set of non-food crops. In the final analysis, their choice of crop will depend on markets opportunities and agronomic constraints.

Finally, care needs to be taken to ensure that, where non-food crops are to be promoted for their beneficial contribution to the carbon cycle, the concept of bioenergy should be inseparably linked to environmental enhancement.

Agricultural non food production area in the EU (mio ha)
EU12 until 1994/95



Non-food area on set-aside in the EU (Mio ha)
EU12 until 1994/95



June 1999

Memorandum by Goreham & Bateson (Agriculture) Ltd

THE ARGUMENTS FOR INDUSTRIAL/NEW CROPS RECEIVING AREA PAYMENT UNDER THE AGENDA 2000 PROPOSALS

Agenda 2000 does nothing to encourage new initiatives within the industrial crop sector and the present proposals within Agenda 2000 discriminates against such crops.

New and alternative crops for industrial, cosmetic, and pharmaceutical markets would be at a major disadvantage to cereal crops under the proposed Agenda 2000 policy reforms.

If the proposed non-specific crop payment meant exactly what it implies (ie, any arable combinable crop grown on IACS registered land receiving the same rate of aid) then new and industrial crops would be put on a level playing field with IACS crops. In short, it would remove the discrimination which is presently proposed. Further, the cost of such a policy would be exactly the same as presently proposed; there are, therefore, no additional costs, but only benefits.

Under the present Agenda 2000 proposals it is quite conceivable that farming in Britain will move from a relatively diverse situation towards a mono-culture situation, although I know our Ministry presently disagrees with this scenario. There is little doubt in my mind that farmers will be driven by pure economics, and wheat with a "set-aside break crop" will predominate. If this were to occur intervention stocks would increase and the costs of CAP would escalate. It would, therefore, be to the advantage of the whole industry if we were to support new and alternative crops in just the same way as we support wheat—indeed, the growing of a new or alternative crop would merely replace a crop which is presently subsidised.

If compulsory set-aside is removed (as is proposed) then it is logical to allow farmers to grow an alternative crop for industry on such land and still be eligible for aid and, in doing so, there would be no requirement for the putting up of "security bonds" which are presently burdensome and costly for all those involved—the putting up of such a bond would become unnecessary.

Large investments within the United Kingdom and Europe have been put into new and alternative crops, with an emphasis on "renewable resources" and the replacement of fossil fuel raw material feed stocks. It would, therefore, be a "policy gone mad" if such a policy discriminated against the advantages this new investment can bring. Should discrimination against such new technology be incorporated into European policy then the rest of the world would gain the advantage over its European neighbour.

Conclusions

1. The present proposals within Agenda 2000 positively discriminate against initiative. This discrimination will increase costs of the CAP, hand over investment and technological gain to the rest of the world, and do nothing for our environment.

2. By allowing combinable and new crops to receive the area aid, which is presently available to the present COP crops (cereals, oilseeds and proteins), would rectify this anomaly. This would bring further benefits to both consumers, farmers and tax payers.

3. A more diverse agriculture has clear and obvious advantages, both for the environment and for our aesthetic look of the countryside. The English countryside must be one of the major attractions to the Tourist Industry.

Greater diversification within the rural economy will reduce imports and increase exports and protect against unemployment.

I would like to make one final important plea for new and industrial crops. They are presently inherently disadvantaged in that they have not had the benefit of 50 years of subsidised research and, in consequence, a very good argument can be made for additional financial help to bring about the diverse agriculture which would benefit all.

17 March 1999

Supplementary memorandum by Goreham & Bateson (Agriculture) Ltd

I write in response to the House of Lords Select Committee's Weekly Agenda of Friday, 7 May 1999—number 20.

Within the Agenda, specifically in the non-food crops sector, you invite written submissions on a number of questions. My own company is, I believe, more qualified to than many to attempt to answer some of these questions in that my company specialises in the introduction and development of new and non-food crops and we invest heavily in this area, albeit we are a relatively small business with a turnover of only £15 million.

The questions you ask are as follows:

1. *"What is the potential for the development of non-food crops in the United Kingdom"?*

Quite simply, the potential is only significant if the political will to develop non-food crops is itself significant. Any non-food crop starts with a great disadvantge in that there are requirements for both breeding work, more effective processing and market development. One such crop we have high hopes for at present is the crop of woad which produces indigo blue dye. We are addressing all three factors of breeding, processing and marketing. The potential for the naturally produced indigo is several hundred thousand hectares, but the potential can only be realised if there is both the political will and consumer will to purchase a naturally produced product.

2. *"What is their potential to replace other less renewable resources, and to pay their way, in the long term?"*

Within the question the answer is already written, in that the question also refers to the breeding of plants and advances in processing technologies, and it is in this way that cost of production is lowered and consistency and reliability and continuity of product can be offered to the market place. We believe our advances made to date on woad points us in this direction. The potential, therefore, to replace non-renewable resource of indigo is on a one-to-one equal ratio basis.

3. *"What are the environmental and ecological implications of the development of non-food crops?" "How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?"*

Since my letter to you is so far mainly directed at the crop of woad then I can tell you that the crop has, to date, shown nothing other than environmental and ecological advantages, particularly in the processing methods of the prime materials, ie we can produce natural indigo without any toxic materials produced in the process and, in consequence, it differs very greatly from conventional processing methods which have ecological costs attached to them in terms of toxic pollution.

4. *"Are there regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?"*

YES—YES—YES. Traditional crops have had the benefit of political and subsidised assistance since the Second World War and consequently have 50 years' advantage in technology. However, if this is not enough they also carry a subsidised advantage in that cereals, oilseeds and proteins all qualify for a subsidy when the crops are grown and what is referred to is IACS registered land. There is, therefore, a great "disincentive" in the current subsidy system, and there is either no or little incentive either in the way of subsidies, or taxation to produce a non-food crop.

5. *"In the light of the above, (a) are the current United Kingdom and European Union subsidies for non-food crops, and the proposals under Agenda 2000, appropriate; (b) are the local, national and European Union regulatory regimes appropriate; and (c) is the level and direction of United Kingdom and European Union public funding for research and development appropriate?"*

(a) Firstly, the United Kingdom and European Union subsidies for non-food crops are presently non existent and the proposals and subsequent regulations passed under Agenda 2000 does nothing whatsoever for non-food crops.

To listen to our own Government who would argue that non-food crops are not disadvantaged when they are grown on set-aside land is a nonsensical argument. If a farmer can earn £106.00 per acre for doing nothing as opposed to risk a loss from a new and non-food crop then to a small business this is a real factor within a decision making process. In addition the bureaucracy and costs attached to growing any non-food crop on set-aside land is nothing short of horrific and requires massive administration and incurs risks of enormity and provides disincentive. I cannot emphasise this point strongly enough.

(b) In a word—the answer is NO. Not only are the regimes appropriate, there simply are not any for the majority of non-food crops.

(c) I find this very last question the hardest to answer in that I might be arguing from ignorance but, nevertheless, I will offer my opinion. My own company has been very successful in becoming part of research funded projects and this is helping with our research tremendously. However, it seems to me that if there is a willingness to change the face of agriculture and to promote non-food crops which can bring enormous benefits, both to the rural economy and to the consumer, then we need a system which encourges the "entrepreneur" to make things happen. My only reservation about the present research and development project of which we have had experience with, have been promoted by academic institutions instead of the other way round. What I am trying to say (probably very badly) is that I think the funding for research and development ought to emphasise "development" and be entrepreneurial led and the academic institutions become partners in that initiative as opposed to the other way round.

I hope my comments are useful and I would be very willing for my company to be represented at any meeting which will further the interests of establishing a co-ordinated future for non-food crops which I fear presently does not exist.

Robert A D Bateson
Managing Director

11 May 1999

Memorandum by Professor F D Gunstone

This report is submitted by Frank Gunstone on an individual basis and is limited to the use of vegetable oils by the oleochemical industry. I have studied lipids (oils and fats) for over 50 years in the Universities of Liverpool, Glasgow, and St Andrews. I am now Professor-Emeritus of the University of St Andrews and Honorary Research Professor at the Scottish Crop Research Institute (Dundee). I still act as a consultant, lecturer, review writer, and writer and editor of books devoted to many aspects of lipid science. I am also editor of the magazine Lipid Technology which started in 1989. I am not best-fitted to answer some of the questions in your Call for Evidence but I present some background material which may assist your discussions. Wherever possible I have provided numerical data to give the right balance.

Oilseeds as Non-Food Crops

Introduction

The world supplies of lipids are now just above 100 million tonnes per annum. These come from 13 vegetable oils (79 per cent) and four animal fats (21 per cent) and are used for food (81 per cent), animal feed (5 per cent), and for oleochemical purposes (14 per cent). The leading vegetable sources—becoming more dominant every year—are soya, palm (and palmkernel), rape/canola, and sunflower. Other vegetable oils grow in volume each year but are decreasing in market share. These include oils from groundnut, cottonseed, coconut, olive, corn, sesame, linseed, and castor. This listing is based on the publications of Oil World (Hamburg) and does not include cocoa butter and many minor oils.

Lipids for non-food use

The oleochemical industry, using $\sim$14 million tonnes of oil/fat each year from both animal and vegetable sources, is based on oils used almost entirely for industrial purposes such as linseed and castor and also on some of the major food oils, especially soya, palm, rape/canola, coconut, palm kernel (and tallow).

The exploitation of lipids already available in large quantities for non-food use is being pursued aggressively in the United States for soybean oil and in Malaysia for palm oil. Similar activity in the United Kingdom would have to be based on rapeseed oil since this is the only oil produced at high levels. There are active public sector research centres devoted to oleochemicals in Germany and in Holland but none in the United Kingdom where limited research in this field is confined to the private sector.

Fatty acids (basic units of lipids) are amphiphilic substances and therefore have important surface-active properties. Traditional soaps, used for centuries, are now accompanied by a wide range of other surfactants produced by the oleochemical industry. Indeed 90 per cent of the output of the oleochemical industry is some form of surfactant. These compounds are used domestically in the bathroom and the kitchen, for industrial cleaning, and in the agricultural, cosmetic, and pharmaceutical industries. Lipids and lipid-based compounds are also used in surface coatings (paints and inks), as lubricants (more surface-activity), adhesives, solvents (for cleaning oil-spills), in plastics, and as biodiesel which can be used as an automotive fuel or as heating fuel.

Lipid-based products have some significant virtues based on their environmental impact: (i) they are easily bio-degraded so that when they are finally discarded they do not remain for long in the environment; (ii) they come from a renewable resource in contrast to material based on fossil supplies, not renewable on a human timescale; (iii) when burnt as biofuel they release carbon dioxide trapped only months before, in contrast to fossil fuels. However other matters have to be born in mind. Even the growing of a crop has an environmental cost and this is increased by transporting it around the world. The annual production of lipids (about 100 million tonnes) is only 3 per cent of the annual production of oil and of coal. Oleochemicals may have special uses and be environmentally attractive in certain situations but they can have only a trivial effect on total demand for fossil-based fuels and products.

New crops

It is well known that man makes very limited use of the wide range of plant species available in nature. As indicated in paragraph 1 virtually all traded oils and fats come from only 13 species of plants. Many other species produce seed lipids in good yield though most of these have a composition not very different from the existing supplies. There are, however, other oils which are novel in character and for which new uses would have to be developed. New commercial crops are now being developed in three ways.

Domestication of wild crops. This, of course, is the route by which we have obtained our present major crops, whether grain or oilseed, and this continues today with crops known only in the wild state or as ornamentals. Agronomists take 10-20 years to convert a wild plant into an economic crop. Examples of oilseeds being developed in this way are discussed below.

Conventional seed breeding of already-domesticated crops. This is going on all the time and leads to improved varieties giving, for example, higher yields, stronger resistance to disease, shorter growing seasons, better over-wintering properties as well as changes in lipid composition. An important example for the lipid scientist/technologist is the conversion of high-erucic rape seed oil (with undesirable nutritional properties) to the double zero varieties (low in erucic acid and low in glucosinolate) which is now grown widely throughout Northern Europe and especially in Germany, France, and the United Kingdom. European production of rapeseed was 0.50 million tonnes per annum in the five year period 1968-72, 0.88 million tonnes ten years later (1978-82), 2.33 million tonnes after another ten years (1988-92), and ~3.09 million tonnes at the present time.

Genetically modified plants. Most developments in genetically modified oilseeds have been for "agronomic reasons". These include herbicide tolerance, male sterility, and insect-, viral-, fungal-, and bacterial-resistance. Of greater interest to lipid scientists/technologists is the possibility of producing oils with novel fatty acid and triacylglycerol compostion. The best known example is laurate-canola which is a rapeseed plant producing a laurate oil (like coconut and palmkernel oil). Many other modifications are being pursued, mainly in the United States, and designed to produce oils with improved nutritional properties. It is worth noting that by concentrating on a few species such as oilseed rape this further limits biodiversity. But it is attractive to the farmer who is asked to grow a crop with which, in agricultural terms, he/she is already familiar and who considers growing completely novel crops to be much less attractive (more risky).

Already there is interest in several new oilseed crops, some of which are being developed for non-food use. Developments are concentrated in United States of America and in Europe (particularly Holland). They include:

Cuphea species (short and medium chain fatty acids)	detergents
Erucic acid-rich rapeseed oil	plastics
Crambe (erucic acid)	plastics
*Coriander (petroselinic acid)	nylons
*Calendula (calendic acid)	see below
Camelina (several acids)	see below
*Lesquerella (hydroxy acid)	alternative to ricinoleic acid
*Dimorphotheca (hydroxy acid)	uses to be developed
*Vernonia oils (epoxy acid)	uses to be developed

Those marked with an asterisk contain unusual fatty acids and for most of these new uses will have to be developed. Not all of these will be suitable for cultivation in the United Kingdom.

The example of calendula oil is typical. Attempts are being made to extend the planting of calendula in the Netherlands to about 10,000 ha in year 2000, to raise the oil content from its present level of 18 to 20 per cent to ~25 per cent, and seed yields to around 3 t/ha suggesting production of 7,500 tonnes of oil. This oil contains ~55 per cent of the conjugated triene acid calendic (8t10c12c-18:3) and ~20 per cent linoleic acid and can be used in resins and paint formulations leading to reduced VOC emission. There is also the possibility of growing this plant in the South of England.

Camelina sativa, also known as gold of pleasure and false flax, has a long history and is being rediscovered as an oilseed for agriculture in North West Europe. It is seen as a valuable break crop between consecutive grain harvests and is remarkable for its low requirement of herbicide, pesticide, and fertiliser. The seed contains about 40 per cent of oil and oil yields of 2.2 t/ha are quoted. The oil may be used in animal feeds to enhance the level of linolenic acid, in cosmetics, and has potential food and non-food uses. It has recently been accorded food status in France and the United Kingdom.

Footnote

Since preparing this submission I have been able to read Non-food Crops (POST 125, March 1999). I have some problems with the figures on page 1 relating to linseed and oilseed rape (OSR).

Traditionally linseed contains a highly unsaturated oil rich linolenic acid (triene) with industrial uses based mainly on the ease with which it is oxidised and polymerised (as in linoleum, paints and varnishes, etc). There is now a different form of linseed (generally called linola) which is low in linolenic acid and rich in linoleic acid (diene). It has a composition very similar to that of sunflower seed oil and is used as an alternative to this oil in polyunsaturated spreads. This is clearly a food oil but in the statistics available to me the two forms of linseed are not distinguished. I do not expect that linola is yet a significant proportion of the linseed grown in the United Kingdom but considerable quantities are being grown in Canada. This is not a genetically modified seed but the product of chemical mutagenesis followed by conventional seed breeding.

The major form of OSR is the low erucic variety (double 00) but the high erucic variety is also grown for oleochemical use. Does the 28kha of non-food rape refer to this material or is it a description of rape grown only on set-aside land whether this is high erucic or low erucic oil? The high erucic oil is grown only for

oleochemical uses: the low erucic oil is grown mainly for food purposes *but it can and is used for non-food purposes*. These include biodiesel (RME or rape methyl esters), use as a lubricant, and as an epoxidised oil.

The production of these two oilseed crops in the United Kingdom is reported in Oil World Annual for 1998 at the following levels. I believe that these refer to all the varieties of both oils.

	97/98	*96/97*	*95/96*	*94/95*	*93/94*
Area kha					
Rape	472	414	439	496	421
Linseed	76	55	62	67	156
Oilseed kt					
Rape	1523	1410	1235	1254	1256
Linseed	106	86	81	78	180

26 March 1999

Memorandum by Horticulture Research International

First, my sincere apologies for the delay, and not responding to your "Call for Evidence" on Non-Food Crops by the end of March 1999.

I was moving appointments between SCRI and HRI, and wished to provide a response on behalf of both organisations, although I remain personally more familiar with the SCRI programme (above).

Nevertheless, a quick "straw!" poll of new senior colleagues at HRI, Wellesbourne and East Malling, elicited the following brief responses and observations which can be amplified, if Sub-Committee I of the House of Lords Select Committee on Science and Technology so wishes.

1. HRI (Science Director's Group) will shortly be involved in developing crop virus-based protein expression vector systems for non-food uses, to liaise with former colleagues at SCRI, Dundee, with Bioscource Technologies Inc, as well as with other United Kingdom and European Union research groups active in this important new area.

2. HRI has major R&D activities and commitments to ornamental (amenity) crops (protected and alfresco), and to woody perennial crops for non-food uses. Further details are provided below.

3. At HRI, East Malling, MAFF-funded work is underway on the genetic improvement of farm woodland species (for hardwood timber). Also at HRI, East Malling there is a commercially funded programme on the genetic improvement of timber for bioenergy.

4. As strong entomological input at HRI, Wellesbourne, notes that novel crops will have the invertebrate pests, which must be controlled. Also, new crops and new cropping practices will have an impact on arthropod communities in the agroecosystem, which should be explored.

5. If global warming occurs, colleagues at HRI Wellesbourne and Efford suggest that sunflower could become a more economic proposition; especially if genetically improved by GM or conventional breeding for United Kingdom conditions for industrial feedstock requirements.

6. HRI Wellesbourne and the University of Bristol have an early stage research student project to introduce virus resistance into surfinia Petunias. Although of relatively low economic value, the PR benefits could be significant (for GM) because of extensive horticultural media publicity given to virus problems in surfinias. Similar GM work could be undertaken in Narcissus and other ornamental species, where the United Kingdom is in greatest competition (as with much horticultural R&D) with The Netherlands.

7. Production of fast growing combustible biomass crops is favoured to replace fossil fuels and to offset a global rise in carbon dioxide levels. Growing willow in short rotation coppice is now well established in the United Kingdom and the potential for other crops such as miscanthus or reed canary grass for fuel or fibre is being evaluated. However, the projected yields of these crops are seldom realised and can be only half that predicted (eg as little as 8–10 tonnes/ha/annum for willow). The reasons for this are: (i) higher yielding varieties may not be suited to United Kingdom conditions; (ii) there can be serious insect damage (midges, beetles) which restricts biomass production; and/or (iii) yields may be limited by excessive or inadequate water supply. Heavy soils prone to waterlogging restrict dry matter production, and shortages of water on lighter soils in summer can reduce transpiration. Short rotation coppice can also have a major detrimental impact on soils if harvested between October–April, when the soil is wet. The use of heavy mechanised equipment can cause serious compaction, leading to long-term soil structure problems which may then have a delerious effect on regrowth of the willow directly or indirectly through reduced water availability to the crop.

Professor T Michael A Wilson
Science Director (previously Deputy Director of Scottish Crop Research Institute)

9 April 1999

Supplementary Memorandum by Horticulture Research International

1. I am responding as a named co-inventor on the international suite of patent applications filed by the Scottish Crop Research Institute/Mylnefield Research Services Ltd, on the plant viral OVERCOAT® protein expression system. High copy-number plant RNA viruses, comprising rod-shaped, helically symmetrical particles, such as potato virus X (PVX) or tobacco mosaic virus (TMV) are used to express transiently, and rapidly, large amounts (hundreds of milligrams to several grams per kilogram fresh tissue weight) of foreign peptides, polypeptides or even intact functional proteins as freely soluble proteins in the infected plant cells, or as contiguous, covalently attached moieties on the outer surface of a subset of viral coat protein sub-units used to construct each infectious progeny virus.

2. At the outset, I should correct a significant factual error in POSTNote 125 (March 1999; p 7, last paragraph, right-hand column). Apart from the DNA of the transcription template used to produce full-length, infectious recombinant viral RNA genomes for primary inoculation of leaves, DNA is not required. Thus the OVERCOAT® method does *not* involve "transferring DNA using plant viruses. Moreover, the foreign protein coding sequence (gene) does not become integrated into the chromosomal DNA of the host plant. Further details of the OVERCOAT® system are provided below and on the documents enclosed.

3. Patents protecting this invention are now becoming granted or agreed (eg 25 February 1999, in New Zealand). To assist with biological containment, we have intentionally harnessed plant RNA viruses which are not spread *via* pollen, seed or invertebrate vectors (see enclosed review by Lacomme *et al,* 1998 in Genetic Engineering 20, 225–237. Plenum Press, New York).

4. Given our high quality science and technology base, the United Kingdom has great potential to develop economically valuable, specialist crops for non-food uses. In particular, the strong United Kingdom pharmaceutical industry and biomedical research community could provide advice, support and the impetus to harness edible or non-edible crops for specific therapeutic or prophylactic medicinal (human or veterinary) applications. Medical, dental, veterinary, environmental and bioremedial "non-food crop" applications are becoming increasingly apparent and being reported in high-profile refereed journals (eg see *Nature Medicine,* May 1998 issue). Nevertheless, the requirement to grow GM crops, or GM virus-based expression vectors in non-GM host plants, under strictly monitored, contained-use conditions in the United Kingdom and European Union is likely to restrict their overall impact on open land-use issues for the foreseeable future.

5. It should be recorded that a United States of America biotech company, Biosource Technologies Inc, Vacaville California, has recently invested in a three-year programme of collaborative research and development (involving 11 new research posts) with former colleagues at the Scottish Crop Research Institute, Dundee. The principal aim is to refine and further exploit their proprietary TMV-based GENEWARE® protein expression and functional genomics technologies alongside the SCRI OVERCOAT® system.

6. For the past nine years, Biosource scientists have been mechanically inoculating conventional (non-GM) tobacco plants with infectious recombinant TMV genomes, each expressing a unique foreign protein. For the last few years this has been done in open field sites at Owensboro, Kentucky, adjacent to their commercial-scale tobacco leaf extraction and foreign protein purification facilities (the most recent costing about $20 million and capable of processing three tonnes per hour). This work has been undertaken with full USDA and EPA participation in the design, safety monitoring and regulatory approval processes. Recently, Biosource were given permission to scale-up their GM-TMV-infected tobacco plots to 1,000 acres, if required; and received "fast-track" approval to use any of their TMV-based GENEWARE® vectors containing a wide range of commercial target protein genes. Among their disclosed targets are an enzyme to remedy the gene deletion (lesion) responsible for human Fabry's disease (alpha-glucosidase), and tailored, patient-specific vaccines to mobilise immune defenses against surface proteins from indolent non-Hodgkin's lymphoma cells.

7. Non-food crops will soon become cheap, safe and readily available sources for therapeutic or prophyactic proteins or other functional molescules, to complement or replace the use of transgenic animals (raising fewer ethical and welfare issues), or extracts from specific tissues or organs (eg from cadavers), or the products extracted from outdated, pooled blood donations (less risk of contamination by human or animal pathogens, eg HIV, prions etc).

8. GM non-food crops, or regular crop plants (edible or in-edible) internationally infected with a GM-virus, may also provide significantly cheaper sources of efficacious proteins or secondary metabolites, through biochemical pathway engineering, than continuous or batch microbiological cultures (bacteria or yeasts) in complex sterile media, or immortalised human or animal cells cultures (eg hybridomas) in expensive growth media (eg foetal calf serum). For example, we recently published results demonstrating that a suitable GM plant virus (PVX) resutled in an OVERCOAT® of a single-chain recombinant monoclonal antibody (scFv) which specifically recognised the pre-emergence herbicide, diuron (Smolenska *et al,* 1998 FEBS Letters, 441, 379–381; enclosed). This was a convenient model study. However, any scFv against any cognate target could theoretically be expressed *in planta* by OVERCOAT® or standard GM technology.

9. In addition to proteinaceous products, non-food crops can also be genetically engineered, or GM-virus infected, to produce and accumulate any of a vast range of secondary metabolites, pigments, carbohydrates or lipids by constitutive, inducible or transient metabolic engineering. Thus even specialist non-food crops

have the potential, even under limited contained-scale use, to replace other less renewable resources and to pay their way (Question 2).

10. There is no reason, *a priori*, why crops for medicinal use should be restricted to tobaccos; although this was the plant of choice not only for early facile transformation/regeneration methods, but also for Biosource Technologies Inc and their field-scale GENEWARE® technology. The Sub-Committee should also be aware of the elegant work by Dr Julian Ma and colleagues at Guy's Hospital, Medical and Dental School, London, who created secretory antibodies against the causative agent of dental caries using GM tobacco plants. To do this, they crossed, pairwise, four independent, single gene transgenic plant lines to combine and self-assemble the four polypeptides of a mature secretory antibody molecule.

11. There are limitless opportunities to exploit pairwise combinations of GM plants, GM viruses in non-GM plants, etc to produce valuable products in truly "non-food" crops, or in edible crops, but for limited, high value "non-food" niche markets (eg vaccines in raw carrots, tomatoes, apples etc), using either a suitable virus or "standard" GM methods. Further examples might include Brassica species as animal feed to treat parasitic infestations of the G.I. tract. Applications such as this would be especially suitable for developing (tropical) countries, where cost, ease of shipment, storage and application are key.

12. Issues of yield, reproducibility and genetic stability (especially when using an RNA virus-based expression system) are currently being addressed experimentally by several groups in the United Kingdom and elsewhere.

Professor T Michael A Wilson
Science Director (previously Deputy Director of Scottish Crop Research Institute)

29 March 1999

Memorandum by IACR (the Institute of Arable Crops Research)

A response is made to each question posed by the Sub-Committee taking account of their request that: (1) they wish to complement other current investigations of bioenergy by examining energy crops in the wider agricultural context and (2) they prefer short submissions.

1. Potention for the Development of Non-Food Crops in the United Kingdom: Crops Likely to Prove Significant in Terms of Economic Activity and Land Use

1.1 *Small scale, high value crops for specialist oils and other plant extracts*

The use of essential oils and other plant extracts is increasing steadily and estimates by Biosys Ltd suggest that it might double over the next five years. To meet market demand for extracts from organically grown plants (for which there is a considerable premium) appropriate production methods need to be developed.

Recent IACR research indicates that new plant products could include chemicals that affect insect and mollusc behaviour. For example, plants in the Labiate family (Lamiaceae), including catmint (*Nepeta cataria*), have the potential to provide a source of the aphid sex pheromone. This chemical can be used to attract aphid natural enemies and thereby provide enhanced levels of biological control of these pests, substituting for pesticides in conventional and organic production systems. Our research over the longer term aims to extend this work to include other pest pheromones for crop protection and to control vectors of human pathogens. Natural plant-derived compounds that interfere with normal feeding behaviour of crop pests (antifeedants) are also potential products for pest control, in the short to medium term.

Traceability of supply will be essential for plant products. Crops grown for essential oils and other specialist products will probably not exceed 100,000 ha. However, some of these crops thrive best on relatively poor soils that are marginal for food crop production. Generally, higher labour inputs are required than for food crops (possibly double that of cereal production), thus providing increased rural employment.

1.2 *Low value biomass crops for energy and fibre, particularly willows and grasses*

Biomass crops for energy and fibre are the only non-food crops likely to be significant in terms of land use over the short to medium term in the United Kingdom. Willows grown as short-rotation coppice (SRC) are likely to be the major biomass crop initially, but fast growing grasses such as *miscanthus* are likely to be more suitable crops in certain areas. Current research in IACR includes an European Union-funded investigation of combined food and energy systems in which SRC willows are grown in 12 metre-wide strips in arable fields. The aim is to explore interactions between SRC willows and food crops and identify any potential benefits or disadvantages from growing willows in this way, as an alternative to conventional field margins or so-called "beetle banks". Results in 1998 indicate that, for example, there was a potential benefit from an early season build-up of ladybird larvae feeding on willow aphids. When they emerged as adults, these ladybirds were then able to move into the adjacent food crops to feed on aphids. Benefits to willow strips from the adjacent food crops were also identified: new willow shoots growing in spring 1998 from cut stumps appeared to be hidden from willow beetles by surrounding, higher-growing, autumn-sown food crops and insect predators of willow

beetle eggs moved from food crops into the willow strips. Recent IACR studies also indicate that *miscanthus* crops provide suitable habitats for beneficial beetles and spiders. Estimates by the Energy Technology Support Unit of the Department of Trade and Industry indicate that 150,000 ha of energy crops will be needed to meet the 10 per cent target of United Kingdom electricity supply from renewable sources by 2010. However, other estimates suggest that such crops could be grown on 600,000 ha (K J Brent, 1998, *Review of Research on Biomass Crops,* MAFF, London, 67 pp). Over the longer term, economic success and commercial exploitation of biomass crops are likely to be based on multiple usage. After harvest a range of higher value natural products will be extracted, such as pharmaceuticals, liquid fuels, dyes, monomers for manufacture of plastic polymers etc, with the waste fibrous material left after extraction being used for fibreboard, cardboard, paper or energy production.

2. Potential to Replace Other Less Renewable Resources and Pay Their Way in the Long Term

2.1 *Industrially valuable fatty acids*

Production of specialist products in plants will usually need to be enhanced by breeding. For some products, this can be achieved by conventional breeding methods aided by the use of molecular markers. For other products, such as unusual fatty acids, transgenic breeding will be required. However, the genes encoding the enzymes required to synthesise some products such as valuable fatty acids have not yet been cloned. Several enzymes are required to incorporate fatty acids into storage oils. The enzymes normally present in plants may select against the incorporation and storage of these unusual fatty acids, necessitating the cloning of genes from other organisms. Unusual fatty acids may be toxic to plants and the enzymes required for their production may be available only from non-plant sources. Nevertheless, production of such valuable and unusual fatty acids in plants should be feasible provided the technology of transgenic breeding it is publicly acceptable.

2.2 *Biomass*

Biomass crop varieties today have been mainly bred for other purposes. Breeding programmes for high yielding biomass willows having been established only in recent years (including a willow breeding partnership based at IACR). No breeding programme has yet been established in the United Kingdom for miscanthus or other grasses, although there are breeding programmes in Europe. Miscanthus is relatively free of pests and diseases in the United Kingdom but the narrow genetic base of this crop means that it could be at risk from new importations or variants of pests and diseases. Thus, new breeding programmes should include genetic diversification as a target. Willow grown for biomass already suffers from a range of diseases and pests, especialy rust disease (*Melampsora* spp.) and leaf beetles (Chrysomelidae). In recent years, new strains of *Melampsora* spp. have arisen that are able to overcome the resistance of willow varieties previously safe from attack, with devastating consequences for biomass yield. Recent IACR research indicates that the severity of attack by *Melampsora* rust can be considerably mitigated by growing willows as intimate, genetically diverse mixtures. Mixtures also provide protection from beetle attack. Over the medium to long term, the effects of diseases and pests can be mitigated by a strategy of breeding new high yielding varieties of willow with a broad genetic basis for incorporation into mixtures. This is a major aim of the willow-breeding programme based at IACR, which also aims to breed varieties of willows with elevated concentrations of products for industrial use.

3. Environmental and Ecological Implications

Non-food crops will enhance the diversity of the countryside, first by increasing the number of plant species grown and secondly through providing habitats for beneficial invertebrates and wildlife. Many non-food crops require low inputs of fertilisers and pesticides, making them suitable for growing in environmentally sensitive areas. Moreover, many can be grown on marginal land where there is currently little opportunity for crop diversification.

Natural plant products may provide benefits in directly replacing environmentally hazardous materials (for example the use of plant-derived aphid sex pheromones for control of aphid pests instead of organophosphorous insecticides). Plant products may also replace potentially hazardous industrial processes. For example, synethetic indigo dye is currently manufactured from aniline, formaldehyde and hydrogen cyanide: substitution of synthetic indigo with plant-derived indigo would reduce the amounts of these hazardous materials used by industry.

IACR research emphasises the need to develop non-chemical pest and disease control strategies for biomass willows, for several environmental and ecological reasons: (1) to preserve the value of plantations for wildlife (eg insectivorous birds); (2) to prevent the development of new pest and disease problems as a result of the destruction of natural enemies (as has happened in other crops, eg apples and pears); (3) to avoid development of pesticide resistance, (4) to permit natural enemies such as ladybirds to build up in willow in early season and move to adjacent food crops. In addition, pesticide spraying is technically difficult and costly.

Biomass crops contribute to a reduction in atmospheric CO_2 and, thus, global warming in two ways. The first and most obvious is that they provide a direct substitute for fossil fuels, thus reducing CO_2 emissions. However, in addition, substantial amounts of carbon become sequestered in soil under both willows and miscanthus (considerably more than under arable food crops), thus contributing to further reductions in atmospheric CO_2 concentrations.

4. Regulatory Barriers

(a) *Are current subsidies and Agenda 2000 proposals appropriate?*

Unable to comment.

(b) *Are regulatory regimes appropriate?*

Biomass crops cannot currently compete economically with fossil fuels as energy sources because the price of fossil fuels does not take account of external costs arising from their use. Initially the industry based on biomass crops will need to be supported to make these crops competitive with food crops. However, as the industry develops the cost will diminish, particularly as newer, higher yielding varieties are introduced and as opportunities for extracting high value products from biomass crops are identified and exploited.

(c) *Is the level and direction of public funding for R&D appropriate?*

Increased levels of public funding will undoubtedly provide improved prospects for the United Kingdom to create wealth from non-food crops, not only from crops grown in the United Kingdom but also through royalties on crops grown in other countries. Co-ordinated research effort is essential to provide support for industries based on non-food crops.

Ian Crute
Director, Institute of Arable Crops Research

March 1999

Supplementary memorandum by IACR (Institute of Arable Crops Research)

RESEARCH AT IACR-LONG ASHTON RESEARCH STATION ON WILLOWS FOR SHORT-ROTATION COPPICE AND BIOREMEDIATION

Willows (*Salix*), comprising over 300 species, show extensive variation in growth, physiology and biochemistry. This rich diversity underpins a versatility of uses from basket making, cricket bats and fibre, to short rotation coppice (SRC) and bioremediation. Research at IACR—Long Ashton (funded by BBSRC, European Union, the Environment Agency, MAFF and industry partners) aims to underpin the use of willows as SRC and willows for bioremediation.

Much research focuses on SRC, which has environmental and socio-economic benefits. SRC trees are planted at high densities, then harvested (coppiced) every three to five years. The cut stems are chipped and burnt for heat and to generate electricity. Increased bioenergy production is a priority in Europe, with a target equating to plantings on 8 per cent of European Union agricultural and forestry land (10 million hectares) by 2010. Improving biomass cultivars and pest and disease management are thus crucial research aims.

Genetic Improvement of Willow

The European Willow Breeding Programme was established at IACR—Long Aston in January 1996, by a partnership of Long Ashton, Murray Carter and Svalöf-Weibull AB (Sweden), to produce high yielding, disease and pest-resistant varieties. Since then, 610 crosses have been made between representatives of 24 willow species from the National Willows Collection maintained at LARS. Over 25,000 seedlings have been screened and the best 5–10 per cent selected and advanced to large-scale field trials for further evaluation. Yield trials of the best 10–15 varieties will be established and from these one or two should be released by 2005.

The work on breeding is underpinned by molecular marker technologies. Many biomass willow clones are closely related genetically and can be difficult to distinguish using traditional morphological criteria. AFLP, the multi-locus fingerprinting technique developed by Keygene, is now used routinely for the identification of willow species, hybrids and varieties. This allows removal of duplicate individuals from the National Willow Collection and avoids repetitive crossing in the breeding programme. A preliminary genetic map from a population scored for rust resistance is being constructed using AFLPs and bulked segregant analysis is being applied in an attempt to isolate rust (*Melampsora* spp.) resistance markers.

Twenty highly polymorphic single-locus microsatellite markers in *Salix* have been developed and tested. These co-dominant markers can detect the presence of different alleles at one or more loci on homologous

chromosomes and are amenable for use in databases. Further microsatellites are being characterised for identification and mapping of willow.

Willow Diseases and Pests

Rust, caused by *Melampsora* spp, is the most damaging disease of SRC willows. Fourteen pathotypes have been identified, some infecting several varieties. New pathotypes, capable of causing severe disease on previously resistant willows, have evolved in recent years. In monocultures there is aggressive disease spread within a plantation but data from mixed plantings show consistent trends for delayed rust onset, reduced rate of rust spread, lower final rust severity and higher biomass yield when compared to monocultures of the same varieties. Rust pathotypes become more diverse as plantations mature, but there is no evidence yet for any major shift in pathogen composition, or the development of "super races" as a result of deploying mixtures.

Leaf-feeding chrysomelid beetles (*Phratora vulgatissima, P vitellinae* and *Galerucella lineola*) are the most serious pests of SRC willows and can cause complete defoliation in extreme attacks. Beetle species differ in their feeding preferences, but most recommended SRC willow varieties are susceptible to one or more beetle species. Fewer beetles were shown to infest willows in mixed plantings compared to the same varieties grown as monocultures, with lower densities as the number of varieties in mixture increased from three to five and the structural composition became more random. Mixtures, therefore, also appear to have considerable potential value for limiting chrysomelid damage.

The population genetics of *P vulgatissima* and *P vitellinae* are being studied to provide further insights into their dynamics. A set of 13 microsatellites have been isolated and are being used to investigate population structure at several sites containing willow hosts for which the beetles have different feeding preferences, with sites separated by different distances.

Potential of Willow (Salix Viminalis) to Decrease Unwanted Nitrate from Soil Water in Riparian Buffer Zones

SRC willow has great potential for nutrient retention and pollution amelioration in natural riparian buffer strips. Root tips of willow survive anaerobic waterlogged soil with sub-zero redox potentials for at least two weeks, which explains, in part, how the species can grow vigorously in riverside plantings. Such plantings have potential for decreasing the amount of nitrate entering the river in polluted water draining from adjacent farmland. Laboratory experiments showed that willow can withstand atrazine pollution at levels exceeding those found in farm drains and is also capable of removing substantial amounts of nitrate. Nitrogen in nitrate absorbed by the roots was transported to shoots in xylem sap as amino acids and glutamate with approximately 50 per cent as nitrate. However, as external nitrate supply was raised, the proportion of nitrogen transported to the shoots as nitrate increased substantially. In solution culture tests, three categories of nitrate removal were identified: (i) nitrate neded to sustain root and shoot growth (growth nitrate) absorbed in association with increased activity in roots and shoots of the enzyme (nitrate reductase); (ii) nitrate absorbed by roots and transferred to the shoots in amounts that exceed short term requirements for growth (luxury nitrate) but with no further increase in nitrate reductase activity; and (iii) nitrate transformed to other forms of nitrogen and lost from the system (discard nitrate). Discard nitrate was by far the largest category when external nitrate supplies exceeded 1 mM and was probably lost in volatile forms, including ammonia and nitrous oxide. These possibilities are being investigated by laser analysis sensitive to one part per billion through the European Union Life Sciences Trace Gas Facility at the University of Nijmegen, the Netherlands.

Dr Angela Karp

May 1999

Memorandum by ICI (*see also p 148*)

Introduction

ICI's continuing businesses are National Starch and Chemical, Quest, Uniqema and Paints with major manufacturing facilities principally in the United States of America and Europe. Each has a different proportion of its product range which is derived from renewable vegetable resources. These products are sold into a range of markets including: adhesives, packaging materials, fragrances, flavours and food ingredients, personal care products, surfactants, lubricants and surface coatings.

In many cases the proportion of raw materials that are derived from crops is quite small and may be associated with developmental work. Crop-based resources for larger scale use, eg starch from maize and tapioca, oils from palm and coconut, are sourced from parts of the world where they are grown easily (United States of America, Southern Europe and the tropics).

Although ICI has from time to time been associated with the development of products derived from non-fossil resources (the original work on "Biopol", the biodegradable polymer derived from poly hydroxybutyrate was carried out at ICI's research centre at Billingham in the 1970s), experience proves that

cost is the main driver for raw material selection in most markets. In some applications (such as personal care), vegetable-sourced material is preferred. Elsewhere, the customer will seek out the cheapest product of the required quality irrespective of its source. At present, products based on renewable raw materials per se do not generally command a premium in the market and customers are demanding competitive prices and better environmental performance. This may change.

Any crop-derived product has to compete a priori against similar products on both performance and cost. Alternatively, a higher price can be realised if the crop-derived product has unique properties.

One issue that detracts from renewable resources is the consistency and reliability of supply. The availability and cost of renewable raw materials is strongly influenced by external forces such as subsidies.

The economic viability of any crop will depend on four main factors:

— cost;
— performance;
— reliability; and
— consistent quality.

1. *What is the potential for the development of non-food crops in the United Kingdom? Which crops, if any, are likely to prove significant in terms of economic activity or land use?*

There is global potential for the development of new and improved products from renewable materials such as oils, fats, proteins, carbohydrates, terpenoids and plant fibres. Most of the raw material crops likely to be of significant interest to ICI are those which can be grown in warm climates. Any United Kingdom developments are likely to be associated with small-scale or niche applications.

2. *What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg by genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability be overcome?*

Plant breeding, using either traditional or modern biotechnology, may well produce desirable substances with useful characteristics. It is essential that any such developments are subject to rigorous and responsible risk/benefit analysis. It is likely that the development of such crops would give rise to quite small scale plantings for high added value materials: traditional plant breeding may well be the most cost-effective route to such products.

A good example of a development in the United Kingdom has been the successful classical selection for high erucic acid characteristics in oil-seed rape to yield a new and valuable non-food crop. Oil-seed rape is the main oil crop grown in the United Kingdom. There are two main varieties grown, low erucic acid rape for human and animal consumption and high erucic acid rape for the production of erucamide, used in lubricants. Both varieties are the result of selection by classical plant breeding for the desired characteristics.

Further non-food crop development in the United Kingdom will depend critically on European Union policy and the reform of the CAP. The policy towards non-food crops will affect the price and availability: stability in both is what matters to industry. Erratic crop subsidies will obviously affect the viability of any particular product. Ultimately, like any other product, it will be the cost and technical performance of the crop-derived products that will determine their success in the market place.

As long as hydrocarbon prices remain relatively low, the performance of products derived from non-food crops will be crucial to their commercial success. The improvement of processing technologies in, for example, obtaining higher yields, or in generating less waste, or in easier handling, could result in better competitiveness against non-renewable resources. This, however, will be a secondary effect.

A key issue for further industrial development is a better understanding of what materials might be available from crops—what yields, what cost? A reference mechanism which links potentially desirable properties with sources will foster the development of crop-derived products. ACTIN, for example, is already active in promoting this exchange.

The commercial production of a new material from a non-food crops involves a number of experts—the seed grower, the farmer, the extractor/wholesaler, the industrial company and finally the application specialist. Good communication is essential to develop relationships between these expert groups and again, ACTIN should continue to facilitate such contacts.

3. *What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?*

We prefer the term "sustainable resources" rather than "renewable resources"; we include socio-economic criteria as well as environmental and ecological ones.

Important issues include:

- increasing monoculture and its effect on biodiversity;
- reducing land use for food crops;
- generating large quantities of waste material;
- the consequences of transporting large amounts of material and concentrating that material to gain the valuable product; and
- the effects on society in general such as landscape change.

Some Life-Cycle Assessment (LCA) has been carried out on materials from non-food crops, eg on detergents derivatives by CESIO (published in Tenside Surf. Det. 32 (1995) 2). Other studies have suggested that vegetable-based materials have a lower environmental impact than petrochemical-based materials. We are not however aware of work done to compare the impact of growing crops in Northern Europe versus the tropics in terms of LCA. With all year round growing conditions in the tropics and an already high yield of the desired substances it is difficult to see how growing the same crop could be competitive in northern latitudes.

LCA does not address fully the potential environmental impact of monoculture. It may be that the production of a few thousand tonnes of "speciality" products may have a modest and manageable impact. Nevertheless, the issue of monoculture must be addressed within the context of overall impact of use of renewable resources.

We believe that LCA is an essential component in comparing plant-derived materials with hydrocarbons to ensure a proper technical assessment of energy and raw material use, and of waste production. Certain uses of renewable materials may not be sustainable—they may be too energy intensive or they may create unacceptable waste.

4. *Are there regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?*

For industry one of the major implications of producing new substances, whether from plants or petrochemicals, is the need for registration. Registration can cost £250,000. It may take over 12 months to complete the base data set. Costs of this magnitude are warranted only in the development of novel materials in areas with very high added value.

However, the replacement of existing products with the same substance derived from renewable sources (eg an identical fatty acid from plants or hydrocarbons) should not give rise to further registration costs.

It is instructive to study the market distortion caused by subsidies and set-aside. Merchants and growers have to lodge bonds for non-food crops which are held as a deterrent to prevent their fraudulent entry into the food chain: it can take two to three years for the money to be refunded—*cui bono?*

In the United Kingdom, there is no incentive for the development of biodegradable packaging material, as there is, for example, in Germany. The costs associated with recycling bio-plastic packaging and non bio-plastic packaging are the same. Given that bio-plastic technologies are relatively novel, they are more expensive than those based on synthetic polymers; current recycling policy will not help to change this.

5. *In the light of the above, (a) are the current United Kingdom and European Union subsidies for non-food crops, and the proposals under Agenda 2000, appropriate; (b) are the local, national and European Union regulatory regimes appropriate; and (c) is the level and direction of United Kingdom and European Union public funding for research and development appropriate?*

(a) As already stated, subsidies and policies that change suddenly and alter the availability and price of non-food crops will have an adverse affect on innovation.

(b) There are high entry costs associated with the registration and introduction of new products.

(c) There must be strong emphasis on the need for plant derived products to demonstrate advantage over those from other sources, either in terms of cost or performance.

June 1999

Memorandum by MAFF (the Ministry of Agriculture, Fisheries and Food)

Thank you for your letter of 3 March and the factual questions on non-food crops issues. For ease of reference I will set out both the questions and our response:

1. *What support does short rotation coppice currently receive, either directly for production or indirectly through subsidies to the power generating sector?*

The Woodland Grant Scheme (WGS) makes grants available as a contribution towards the cost of establishing short rotation coppice (SRC). For SRC planted on land set-aside as part of the Arable Area Payments Scheme, grant of £400 per hectare is payable. On all other land farmers receive a payment of £600 per hectare. In the catchment area of Project ARBRE the Forestry Commission has introduced a locational supplement and grant of £1,000 per hectare is payable on all land. The area eligible for this locational supplement approximates to a 40 mile radius around the Arbre power station. Farmers planting SRC on set-aside land can also claim set-aside payments.

The Non-Fossil Fuel Obligation (NFFO) requires the Public Electricity Supply licensees (the Regional Electricity Companies in England and Wales) to secure generating capacity from specified renewable sources of energy. NFFO provides contracts to generate electricity for 15 year periods. The difference between the cost of purchasing electricity generated from renewables and what would have been the cost of purchasing from a fossil fuel generating station is met from the Fossil Fuel Levy paid by consumers. The levy rate of 0.7 per cent raises about £85 million per annum for all renewable energy projects funded through NFFO.

2. *What is the area of biomass crops grown in the United Kingdom and separately in the rest of the European Union? How does the level of support compare with that given in the rest of the European Union?*

There are currently 500 hectares of SRC planted in the United Kingdom and it is expected that at least 300 hectares will be planted in the Project Arbre region in 1999. Most other Member States depend on conventional forestry for supplies of biomass but Sweden has around 15,000 hectares of SRC. Ireland is currently developing a pilot scheme. France has some interest in the use of SRC for land remediation and has 1,000 hectares of SRC, grown for the pulp and paper industries.

On support, Sweden did provide grants to farmers for the planting of SRC but we understand this ended on accession to the European Union. We are not aware of schemes in other Member States.

3. *What are the areas of fibres and hemp grown in the United Kingdom and European Union and what does the United Kingdom support cost?*

We assume this question refers to flax and hemp. Details are:

FLAX AREAS (HA)

	1996	*1997*	*1998*
European Union	132,005	133,406	166,116
United Kingdom	20,219	19,080	16,800

HEMP AREAS (HA)

	1996	*1997*	*1998*
European Union	13,658	22,670	42,039
United Kingdom	1,697	2,293	2,556

European Union support for crops grown in the United Kingdom in 1997 totalled £1,111,406 for hemp and £10,826,000 for flax. Figures for 1998 are not yet available.

4. *What is the current area of oilseeds grown in the European Union for non-food uses and what is the market value of oils for non-food use in the United Kingdom and in the European Union as a whole?*

Oilseed rape and linseed can be grown on maincrop land for food or feed as well as industrial purposes. No separate United Kingdom figures are available for industrial use. In 1998 the United Kingdom grew 30,000 hectares of oilseeds for non-food uses on set-aside land. In the European Union 420,000 hectares of oilseeds were grown for non-food use in 1998.

The market value of oils for non-food use is commercially sensitive and information difficult to obtain. The value of oil for non-food use is currently said to be 10 per cent below that for food use.

5. *Approximately what is the volume of starch used by United Kingdom industry and what is the proportion produced by United Kingdom agriculture?*

Definitive figures are not available but some indication can be derived from the fact that certain industrial end-users of starch in, eg the paper, chemical and pharmaceutical industries can claim an European Union "production refund" on each tonne of starch which they use to make eligible end-products (not food and drink). In 1997–98 production refund was claimed in the United Kingdom on some 220,000 tonnes of starch, including 152,000 tonnes of maize starch, 46,000 tonnes of wheat starch and 22,000 tonnes of potato starch. It is not possible to say how much of the maize and wheat starch will have been produced in the United Kingdom but the potato starch will almost certainly all have been imported while the maize starch, if not itself actually imported, will have been made from imported maize.

I hope this is useful. Please contact me again if you require anything further.

8 March 1999

Memorandum by MAFF (the Agriculture Departments and the Forestry Commission)

ROLE OF DEPARTMENTS

1. Non-food crops can provide renewable and sustainable raw materials for industry and energy and Agriculture Departments seek to encourage industry to exploit these new market opportunities. In doing so, this supports departmental objectives of promoting economic growth, sustaining and enhancing the rural environment, and underpinning social development in rural communities. A key to this is developing a policy and regulatory framework which ensures that, at the very least, non-food crops are not discriminated against when compared to crops for traditional outlets. This incorporates an aim of securing a more economically rational CAP.

2. Within the Ministry of Agriculture, Fisheries and Food (MAFF) the Alternative Crops Unit was set up in 1994 to stimulate interest in non-food crops and to bring together farmers, researchers, industry and Government. At this time there was concern about the need for farmers to find alternative uses for set-aside land. The emphasis more recently has been on the needs of the market and the ability of farmers to meet those needs. Information is disseminated at agricultural shows, seminars and workshops and through a dedicated Website. At MAFF's Central Science Laboratory an Alternative Crops Group has been set up. This Group co-ordinates the European Union IENICA (European Network for Industrial Crops and their Applications) project.

3. Government has encouraged the development of the Alternative Crops Technology Interaction Network (ACTIN) which brings together industry and research interests. Departments co-ordinate programmes of underpinning research and development which aim to improve the potential of new crops and their use in industrial processes. MAFF has a budget of £1.1 million per annum for R&D on non-food crops. The Scottish Office also supports research in this field. Bids for non-food crops research are considered as part of the wider agricultural R&D programme; in the financial year 1998–99 some £720,000 has been spent on research into non-food crops. DANI also supports an R&D programme on non-food crops and in the past five years has spent an average of £400,000 per annum. There is a LINK programme in this area funding work on competitive industrial materials from non-food crops. The Government has agreed to provide funding of £4 million over five years.

AGENDA 2000

4. Under the changes to the CAP agreed in Agenda 2000, support prices will be reduced and direct payments to farmers increased to help compensate for the price cuts. There will be a new rural development policy. In principle this could provide the basis for a shift of emphasis from production support towards environmental and rural development measures in the future. But only very limited additional funds are to be made available for these purposes.

5. In the arable sector, the area payment for all crops will rise in two stages to 63 euro/t in 2001 converted to an area payment at the cereals reference rate (£280/ha for England at the euro conversion rate applying to 1998 payments) and may increase further in 2002 if the Council decide to make a further cut in the intervention price for cereals in that year. There are exceptions which include oilseeds and linseed. For oilseeds, payments will fall to the standard rate which applies from 2002 onwards with interim rates of 81.74 euro/t in 2000 and 72.37 euro/t in 2001. Maximum Guaranteed Area penalties may apply in 2000 and 2001 but in the event of this happening payment cannot be less than the 63 euro/t rate. For linseed, payments will be 88.26 euro/t in 2000 and 75.63 euro/t in 2001, falling to the standard rate from 2002 onwards.

6. Compulsory set-aside will be retained and the default rate for 2000–06 is fixed at 10 per cent. The Commission and Council will still be able to set a different rate each year if they agree to do so. Voluntary

set-aside is maintained, and the provision for non-food crops to be grown on set-aside land will continue. Set-aside payments may be granted on a multi-annual basis for a period of up to five years. At the time of writing, it was anticipated that the present provision allowing farmers to put all of their land into set-aside if it is used for biomass production will be maintained.

7. The new rural development regulation recognises that rural development and environment should be supported as an integral part of the reformed CAP. The development of non-food crops is included within the scope of the regulation as are other measures relating to the conversion and diversification of farming activities. The Regulation specifically provides for a planting grant for crops such as short-rotation coppice, and may provide a basis for assisting miscanthus, subject to including this in the United Kingdom's rural development plan and securing funding.

Main Non-Food Crops

8. In principle, the Government seeks to encourage crops which could become significant in land use terms, where there is a clear driver for their development, such as the protection of the environment, and which have a prospect of economic viability in the long term. The three main types of crops grown in the United Kingdom which have the greatest potential are energy crops, fibres and oilseeds. There are also a number of other crops producing high-value materials, the market for which is relatively small.

Energy Crops

Potential

9. Energy crops have the greatest potential in land use terms and willow grown as short rotation coppice (SRC) is the species which is most ready for commercial exploitation. Others with potential are poplar, miscanthus and other energy grasses. There are a number of factors pointing to the need to develop energy crops in the United Kingdom. At the 1997 Kyoto climate change conference the European Union agreed to legally binding greenhouse gas emission reductions of 8 per cent, while the United Kingdom subsequently agreed cuts of 12.5 per cent by 2010. The Government also has a manifesto commitment to reduce carbon dioxide emissions by 20 per cent. The Department of Trade and Industry has issued a consultation paper which indicates that the Government is working towards a target of generating 10 per cent of United Kingdom electricity from renewable sources, and hopes to achieve this figure by around 2010.

10. Energy crops have real potential to make a significant contribution to these targets. There are currently 500 hectares of SRC in the United Kingdom and we expect around 300 hectares to be planted in 1999. The planting of 100-150,000 hectares of SRC could generate 500-1,000 MW of electricity and lead to carbon emission savings of 0.25-1.1MtC. This would be equivalent to one-sixth to one-third of the 10 per cent target for renewable electricity. Energy crops could also provide new commercial opportunities for farmers and contribute to sustainable agriculture and job creation in rural areas. Estimates are that around five jobs are created for each MW of electricity generated.

11. Key to the development of the energy crops sector is the establishment of new wood-fuels markets. These are likely to be made up of a range of projects supplying electricity, heat or combined heat and power. The United Kingdom's first wood-fuelled power station is now under construction inYorkshire. Project Arbre will generate 8MW of electricity for the national grid and the fuel supply will require 1,000-2,000 hectares of SRC, the remainder being sourced from forestry residues. Other similar projects being developed might require around 30,000 hectares of SRC. In Northern Ireland the Brook Hall Estate is an example of a smaller development generating heat and power from 40 hectares of SRC, the electricity being sold to the grid. Heating and hot water for Weobley school in Herefordshire are produced from woodchip.

12. Larger scale projects have been helped by the Non-Fossil Fuel Obligation (NFFO) and its equivalent in Scotland, the Scottish Renewables Obligation. These support renewable energy technologies which are not yet sufficiently advanced to produce electricity at prices competitive with fossil fuel power stations. New technologies are subsidised through a consumer levy on fossil-fuel derived electricity. Experience shows that the need for support can be reduced progressively and that these technologies can become more competitive with increasing scale and experience.

Potential for Breeding

13. Significant increases, up to 50 per cent, in the yield of willow SRC have already been achieved through conventional breeding techniques. These breeding programmes need to continue and are expected to achieve further significant increases. Breeding programmes also seek to improve the resistance of the crop to pests and diseases and already a number of varieties are available where considerable improvements have been made. Work is also needed on nutrient uptake and pest and disease resistance. Genetic modification is one tool which might have some potential in this area.

Environmental Aspects

14. On environmental and ecological implications, energy crops are relatively low input crops. Over the whole cycle, they are also virtually carbon-neutral, giving out only the carbon dioxide which they take in as they grow. Used in substitution for fossil fuels they therefore have the potential to contribute to the wider environmental goal of reducing greenhouse gas emissions. Tree crops have the benefit of contributing to biodiversity and they have the potential to be used in bioremediation (cleanup of contaminated effluents on soils).

15. Adverse environmental impacts are not anticipated from the planting of energy crops, but a large scale progamme would make it desirable to introduce further monitoring work in respect of water table effects, nutrient leaching, soil erosion and biodiversity. Some of these effects are particularly relevant to the establishment and cut-back phases of the crop.

16. Concerns about the effect on the landscape have been raised, sometimes by those unfamiliar with the crop. Plantings of SRC and return of land to other agricultural uses, are assessed for their impact on the landscape and such impacts are minimised by sensitive design of the plots. These fall within the scope of the Environmental Assessment Regulations which apply to forestry developments and for which the Forestry Commission is the competent authority. Farmers are not allowed to remove existing hedges or trees and may be required to plant broad-leaved shrubs and trees to enhance the landscape.

Support Mechanisms

17. The main barrier to growing SRC is the high cost of establishment which is in the range £1,600–£2,000 per hectare. Experience in Sweden shows that these costs can be expected to fall as commercial areas of SRC are planted. The Forestry Commission administer the Woodland Grant Scheme, a national rather than European Union scheme, which provides planting grants of £400 and £600 per hectare on arable and grassland respectively. But this stimulated little planting and at the June 1998 Agriculture Council the United Kingdom secured agreement to increase the ceiling, following which the Forestry Commission now pay a locational supplement in the Arbre area, bringing the grant payment to £1,000 per hectare on all land types. When the crop is planted on arable land, farmers may also access set-aside payments. Following a further decision at the June Council, farmers planting multi-annual biomass crops can set-aside their whole arable area for this purpose.

18. Changes to the common agricultural policy and continuing progress in SRC scale economies and cultivation technologies make predictions difficult. Competitiveness with other agricultural activities is key to commercialisation of SRC and it is estimated that production on arable land would continue to require an annual payment in addition to the start-up grant to make the crop interesting to growers. This would be available through set-aside payments. Payments to equalise returns with livestock production would however be less than for arable, as livestock margins are much lower than arable margins.

19. Under the new Rural Development Regulation, there is provision to pay an establishment grant on SRC, and possibly miscanthus. There is no provision for an annual payment in respect of loss of income for SRC planted on grassland, which is the kind of land where the opportunity to plant the crop is the greatest. MAFF is examining this regulation to see whether it does provide an adequate basis to support the development of energy crops. In any case, implementation will depend on securing the necessary resources. The Government will be consulting United Kingdom interests on the next steps.

Research and Development

20. Research by DANI has developed an integrated package for the agronomy and utilisation of the crop. Particular attention has been paid to the use of small scale downdraft gasification which has now been integrated into a CHP system. R&D on energy crops has identified and tested a biocontrol agent for willow rust. A project funded by MAFF, DANI, DTI and the Forestry Commission is evaluating the effect of soil and climate on yields from a number of poplar and willow varieties. 49 sites across the United Kingdom cover the major soil types over a wide range of climatic variations. A MAFF funded project, planned to start in 1999, will assess nitrate leaching from SRC and any implications of increasing SRC plantings in view of the Nitrates Directive.

21. The United Kingdom's seven site miscanthus network provides a unique source of long-term yield data for cropped miscanthus. The germplasm pool for miscanthus has also been extended following collection of material from Korea and Japan. This underpins the development of new varieties with improved yield, disease resistance and winter hardiness. An extended programme of SRC planting would require additional R&D to improve profitability through increased yields, reduce costs and improve pest and disease resistance and the use of clonal stands to reduce the impact of disease pressure. It would also require a programme of environmental monitoring, to check whether the impact of the crops was as benign as expected. The potential of SRC to be used in bioremediation to remove pollutants from municipal wastes is currently being explored in Northern Ireland with support from the European Union Framework 4 programme. As DANI has the longest established plantations in the United Kingdom, these are being used to quantify the nutrient off take in the harvested crop. This work will lead to the development of appropriate fertiliser recommendations.

Fibre Crops

Potential

22. Flax fibre has traditionally been used for textile production, especially in Northern Ireland. More recently however new opportunities have emerged to provide a fibre resource for other industries. In 1998, 16,800 hectares of flax and 2,500 hectares of hemp were grown in the United Kingdom. Most United Kingdom production of flax goes into paper, fibre boards for the construction industry, automotive interior panels and geotextiles (matting used to stabilise land on, for example, motorway embankments). Uses of hemp are similar to those of flax but, in addition, the woody core of the plant can be used for horse bedding and chicken litter. Oil from seeds is used in paints, varnishes, soaps and shampoos. The automotive industry could be a significant market with the potential to replace around 80,000 tonnes of glass fibre. In addition to being beneficial environmentally, fibres from crops could also be a lower cost option, not needing large amounts of energy for their production. Fibre crops have the potential to be competitive where the strength and weight of the fibre are important criteria.

Potential for Plant Breeding

23. United Kingdom breeders have sought to develop varieties suitable to the relatively damp United Kingdom climate and harvesting by means of combine harvester. Flax and hemp plants are amenable to genetic transformation using well established techniques and targets but this is likely to be a lower commercial priority than transformation of other major crops. Possibilities to improve fibre yield or quality are likely to be limited. It might however be possible to improve the retting process, which is essential to most harvesting and processing systems and a strong influence on the quality of fibre produced.

Environmental Aspects

24. There have in the past been concerns about the planting of flax on environmentally valuable sites, including SSSIs. This arose because there is an European Union subsidy which is outwith the Arable Area Payments Scheme so that there are no restrictions on the type of land on which the crop may be planted. With encouragement from MAFF a voluntary industry protocol was drawn up in 1997 aimed at preventing the ploughing up of sensitive land. The effectiveness of the protocol was reviewed after the first year of operation and environmental organisations acknowledged that the protocol had succeeded in avoiding encroachment on sensitive land.

Regulatory and support mechanisms

25. Flax and hemp have their own European Union regime providing an aid per hectare. The rates of aid, up to £535 per hectare for flax and £500 per hectare for hemp, compare favourably with aid of £242 per hectare for cereals. European Union production has risen in recent years, mainly in response to demand from industrial users. The Commission have tended to regard this as inconsistent with the original purpose of this regime which was to support fibre for traditional textile uses. They have not been supportive of the production of flax for industrial uses and have introduced new restrictions including minimum yields for both flax and hemp and compulsory contracts between growers and processors. They have also opposed the approval of aid for newly developed United Kingdom varieties of flax designed to grow well in the damp United Kingdom climate and more suitable to the United Kingdom system of combine-harvesting.

26. Because hemp is a member of the cannabis family only varieties with a negligible narcotic (THC) content, less than 0.3 per cent, receive aid. From the 2000–01 marketing year this will be reduced to 0.2 per cent. In the United Kingdom hemp can only be grown under licence from the Home Office and the cost to the grower is currently £270 per annum, increasing to £320 for 2000–01.

27. The Commission has indicated that it intends to reform the regime in 1999 and further proposals for tightening up are expected. These are likely to include proposals for Maximum Guaranteed Areas, in order to cap the aid available, and lower rates of aid for flax grown for industrial uses. If differentiated rates of aid were to be proposed and agreed the outcome would almost certainly disadvantage United Kingdom growers.

Research and Development

28. Publicly funded fibre research has concentrated on characterising the fibre in relation to the requirements of potential industries. Opportunities for flax and hemp as a replacement for glass fibre in composites have been identified. Work has also identified markets for agricultural materials in the wood products and paper industry. The lack of local fibre extraction facilities was identified as a barrier at an early stage. A MAFF sponsored LINK project has resulted in the development and commercialisation of a machine for the mechanical extraction of fibre from linseed, flax and hemp straw. If this industry develops, this technology will provide the essential link between field and factory. Within the LINK programme MAFF, with industry and academic partners, is now funding work on the development of machinery which

will produce fibres of the quality which can be used for the production of high value textiles. In Northern Ireland, recent research has focused on the development of novel retting techniques, with the aim of producing medium/high quality fibre.

Oilseeds

Potential

29. At the moment the largest area of non-food crops in the United Kingdom is oilseeds. In 1998 28,000 hectares of oilseed rape were grown on set-aside land for non-food uses. Non-food oilseeds can also be grown on land which is not set-aside, although this cannot be quantified. Non-food rapeseed is grown to produce erucamide, a slip agent in plastic films, lubricants and industrial oils. In total 100,000 hectares of linseed were grown in 1998. Linseed oil is used in paints and pharmaceuticals. Oils from some varieties of linseed can be used for food uses and separate figures for this are not available.

30. Following the Agenda 2000 CAP reforms in the arable sector, there may be a reduction in the area of industrial oilseeds grown on set-aside land, since the rates of area payment for cereals, oilseeds and set-aside are due to be equalised by 2002, and market returns from non-food crops are generally less than those from food uses of oilseeds.

31. There is scope for oilseeds to replace petroleum-based products in many applications. Oil from oilseed can be used in surfactants, detergents, lubricants, speciality chemicals and plastics. There is some industry interest in the development of biodiesel, which is produced from rape oil in some Member States, but the Government has not promoted this. Compared to solid biomass it has a relatively low energy yield, and it does not appear to have the potential to be commercially viable without long-term subsidy and exemption from excise duty.

Potential for Breeding

32. Oilseeds have already undergone several years of development through conventional breeding techniques. Genetic modification provides the potential to develop high value products by manipulating the fatty acid composition of the oils. It might also be possible to identify particular market needs and design plants which can meet that need. Examples might include medicines, pharmaceuticals, and feedstocks for the plastics industry. Modification of chemical characteristics could have promising applications for raw materials for the chemical industry. There is considerable information on process technology and modification of plant products in existence. Germany and the Netherlands have led in these developments.

Environmental Aspects

33. Oilseed rape, whether for food or non-food use, is not seen as posing any specific environmental threat, though it is grown in rotation with cereals and other crops in what is seen by many as an intensive system of production. Rape is one of the earliest GM crops being developed for the United Kingdom market and concerns have been expressed about the environmental implications of growing such crops. The Government is addressing these by ensuring that the first farm-scale plantings are limited, and are monitored for possible effects on biodiversity. Energy yields and CO_2 abatement effects on a per hectare basis are low for rapeseed used for biodiesel compared with SRC. However, the environmental benefits may be greater in specific applications due to the non-toxic and biodegradable nature of biodiesel. This is also the case where rape oil is used to produce biodegradable lubricants and hydraulic fluids for use in sensitive environments.

Research and Development

34. MAFF R&D on reducing pod shatter in oilseed rape has resulted in new lines being taken forward for testing by the industry. The innovative approach of combining life-cycle assessment with cost benefit analysis to compare the environmental impact of vegetable oils with mineral oils is seen as a key area for study, where research effort in the European Union is significant.

Other Crops

35. There are also crops which produce high value raw materials for niche markets. These include borage which produces gamma linolenic acid for use in health foods and nutritional supplements, crambe producing oil in the form of erucic acid and used in slip agents and lubricants and woad from which indigo is extracted to produce inks and dyes. They currently occupy around 350 hectares, are not likely to become significant crops in land use terms. Their potentially high profitability mean that their development should primarily be taken forward by industry. The industry have expressed concern about the securities which must be lodged in respect of non-food production on set-aside land, which they say can represent a significant financial disincentive. We have asked the Commission to consider simplifying the arrangements.

OTHER APPROACHES

36. Other approaches to non-food crops are being explored in Northern Ireland including agroforestry, the integration of agriculture and forestry, as an alternative land use option. Current research is encouraging in that after nine years of good tree growth, even at the closest agroforestry spacing (400 trees/ha) no reduction in stock output has been measured and technical problems with tree protection have been largely resolved. Anticipated significant environmental benefits have been confirmed.

37. Support for agroforestry is via the Farm Woodland Grant Scheme qualifying for a maximum grant of £925/ha. It is anticipated that agroforestry will feature as a preferred option within DANI's new Countyside Management Scheme. Farmer interest in this approach is already developing and a number of farmers have committed to it. The potential market for hardwood timber in Ireland is good and will be triggered by a larger amount of hardwood planting currently underway. New trials have recently been established which seek to extend the range of tree species, namely clonal ash, clonal cherry, native cherry, cider apple and poplar.

Ministry of Agriculture, Fisheries and Food
Scottish Office Agriculture, Environment and Fisheries Department
Welsh Office Agriculture Department
Department of Agriculture for Northern Ireland
Forestry Commission

April 1999

Memorandum by Professor J S Marsh CBE

A NOTE ON NON-FOOD CROPS

1. There is nothing particularly novel about using agricultural resources to produce crops for uses other than food. A major sector of the horticultural industry is concerned with amenity flowers and plants. Farm crops are used as fuel, as building materials and as a major source of textiles. However, much of the increase in real living standards since the industrial revolution has come about because society has escaped dependence upon agicultural raw materials. Many of the traditional non-food agricultural raw materials have to compete with industrial inputs based on mineral sources. Despite this they continue to occupy a significant market share in some sectors. In addition a variety of new uses are now emerging as plants are seen as sources of useful chemical substances and even as chemical factories in their own right.

2. Increased non food use can come about because of developments in the market, because of the development of new characteristics within crops or because of policy decisions. Each of these elements influences the current outlook.

3. The most important market change is a tendency for the real price farmers receive for food crops under the CAP to fall. This means that non-food farm products may become increasingly attractive and available at prices which makes them more competitive with other sources of supply. It also presents farmers with the challenge adapt their practices to exploit the most profitable markets they can find for the products they are able to produce. A wide variety of possibilities exist but most of them require farm based raw materials to compete with established industrial alternatives. They may seek to do so on either quality or price.

3.1 Quality represents better fitness for purpose to the purchaser. This may stem from some functional characteristic such as the strength of a fibre or on a non-material characteristic for which the market is prepared to pay, such as the animal welfare or support for local products. For many farm crops variability in functional quality due to disease or weather may represent a disadvantage. Non-material benefits tend to apply to niches within the market and once these are supplied may prove difficult to sustain.

3.2 Competition based on price is unlikely to be straightforward. Many of the industrial competitive products are derived from processes which have involved substantial fixed investments. They may be part of a much larger range of materials many of which could not be replaced by farm based production. Faced by a declining market share companies are likely to cut the price of such products. This defends market share and is likely to continue so long as the price received just covers the variable costs of production. For non-food raw materials which form part of an international commodity market, the clearing price is likely to prove volatile. What seems a potentially useful outlet for a farm product, when the market is firm, may turn out to be wholly unprofitable by the time the goods reach the market.

3.3 The current trend in CAP support prices may well lead to some increased use of farm crops for non-food uses at the margin. However, it seems unlikely that businesses which find it difficult to compete at existing farm gate prices will be able to operate profitably at lower non-food prices for their products. If alternative crops were to be encouraged as a means of protecting farm incomes they could only succeed on the basis of substantial and continued subsidy payments. This seems economically irrational and politically unlikely. Thus any substantial shift towards a greater share of non-food outputs in the mix of farm production in Europe is likely to be associated with further structural change in the industry.

4. The possibilities of tailoring crops to meet exacting industrial requirements has been given impetus by the use of modern biotechnology. Further, developments in this area, together with improved systems of

cultivation and plant protection may make it possible to produce, more reliably, higher yields of crops with preferred characteristics compared with those of the past.

4.1 A wide variety of candidate plants exist and at this stage only a small proportion have been carried through to a point at which their full potential as non-food raw materials can be evaluated. Amongst these are oilseed rapes with chemical characteristics which make them very valuable as lubricants in environmentally sensitive uses or as raw materials for some types of paint. The scientific scope for such development remains very large. There are, however, some problem areas.

4.2 The process of genetically modifying a plant, confirming its effectiveness, multiplying it to commercial proportions and arranging market outlets which reward its superior characteristics is very costly. As a result it tends to need the resources of large organisations which, if they are private companies, must ensure that they generate a profit sufficient to justify their investment. The planned new product has therefore either to be saleable in a large market or to generate a product of very high unit value. Much of the largest volume markets for agricultural products relate to food. There are high unit value markets for cosmetics and pharmaceuticals but the demands for such uses are particularly exacting and the quantities required relatively small.

4.3 To undertake the risks involved in innovation companies need a secure political environment and the ability to protect the intellectual property in their products. Such "patenting of life" raises sharp emotions ranging from anxieties that international companies will become effective monopolists to concerns about the ethical validity of using genes derived from some wild source as part of any commercial product. There are also powerful lobby groups arguing that plant biotechnology involves unacceptable risks for the environment. In commercial terms the political risks seem likely to play a decisive role in considerations of whether it is sensible to invest in creating non-food varieties for the particular circumstances of United Kingdom farming.

4.4 The conclusion to be drawn from this discussion is that there are good reasons to believe that modern biotechnology will enable substantial improvements to be made in fitting plants for commercial purposes. However, the relative scale of the markets suggests that the big prizes are to be won in the food rather than the non-food area. Further, the political risks of developing materials for use in the United Kingdom will encourage investors to target their efforts on other parts of the world. In terms of comparative advantage. United Kingdom non-food agricultural production is likely to be at an increasing disadvantage compared with industrial inputs produced from crops grown in more favourable climates and capable of making full use of plants designed for the purpose.

5. The political concern with non-food crops reflects two pressing anxieties. First, to find some means of maintaining revenues to European farmers in a world in which traditional forms of agricultural protection are increasingly difficult to justify. Second, to promote activities which can be presented as environmentally favourable.

5.1 It was argued above that markets for non-food crops were unlikely to afford any significant relief to the farm income problem or to the need for structural adjustment in the agricultural sector. Policy makers may nevertheless, perceive a possibility of using non-food crops as a means of directing public funds into the farm sector. As international agreements limit subsidised food exports and constrain internal policies for the support of farming, non-food crops may be seen as an area where the environmental benefits are regarded as justifying public support. It is far from clear that this is a valid approach or that it would stand up to scrutiny at the level of international trade negotiations.

5.2 If non-food crops are to be produced competitively they are likely to need intensive systems of husbandry. Because the product is not to enter the food chain the restrictions on some types of crop protection chemical need not be so rigorous. The crops are also likely to need to be produced on a scale sufficient to justify investment in processing equipment, and so to have a visible impact on the landscape. Although it may be claimed that they benefit the environment through absorbing carbon or generating renewable energy, it is difficult to be confident that the net effect on the environment is positive.

5.3 The products of non-food crops are generally tradable items. It would be artificial to exempt them from the normal rules of WTO. Whilst there may well be a case for imposing restrictions on trade which is perceived to be damaging to the international environment or to be based on systems of employment which deny human rights, the arguments that restrictions could be applied to trade in the products of non-food crops in order to make them profitable within Europe seem extremely weak. However, if this is the case the extent to which support for non-food crops could be used to ease the pressure on farm incomes is likely to be heavily curtailed. Investment in research and technology transfer seems likely to be permitted. One off regional aids designed to enable vulnerable areas to attain a degree of autonomous economic prosperity might help with the creation of processing capacity but in terms of the regular routine production of a crop, it seems unlikely that this could escape the strictures of the WTO.

6.0 The implication of this note is that although non-food crops may come to play a larger role in the overall pattern of farm outputs, they are likely to remain marginal to the mainstream activities of United Kingdom agriculture for the foreseeable future. The most promising lines of development stem from the application of modern plant breeding technology to create plants designed for particular purposes but the economic and political climate for such investment in the United Kingdom is unpromising. As a means of avoiding structural change or environmental damage much of the advocacy of alternative crops is misguided.

It would be neither prudent for the economy nor helpful to the farming community to propel the industry in a direction which could all too soon prove to be a blind alley.

John S Marsh

February 1999

Memorandum by Mobil Oil Company Limited

OILSEED RAPE

Thank you for the opportunity to present comments from an oil company. Mobil have been in the forefront of developing environmentally aware lubricants, including those based on oilseed rape, since the early 1990's, and I trust the following points are of interest to the committee. The volumes involved are small and unlikely to become significant for a variety of reasons.

In the short time preparing this submission we have contacted a number of colleagues in the United States of America, Scandinavia and our European research facilities, and whilst there is a good consensus, we don't claim to represent all those involved. This letter is attached to hard copy of e-mail details sent 21 April.

Main industrial uses to date, developed for environmental or technical reasons:

— hydraulic oil;
— cutter bar (chain saw) lubricant;
— specialist metal cutting oil (machine shops); and
— base oil for tunnelling machine grease (outside of tunnelling machine).

The biggest industrial volume, hydraulic oil, will not be successful in Europe due to application reasons.

The next biggest volume, chain saw oil, will only develop if social pressures force its wider use.

A small volume used in a specialist area of metal cutting, is so successful that its future is guaranteed.

An intermittent demand for tunnelling machines will only be used if forced to do so for contractual reasons.

1. *What is the potential for the devleopment of non-food crops in the United Kingdom? Which crops, if any, are likely to prove significant in terms of economic activity or land use?*

Oilseed rape has proved an excellent alternative lubricant in some specialist areas where it has or could displace conventional, mineral lubricants. The potential for development is small because the majority of large volume applications requiring an environmentally acceptable lubricant will use a synthetic ester for technical reasons.

In one niche application, metal cutting, oilseed rape based cutting oil provides a significant economic advantage to the end user, but the amount needed is insignificant in the overall picture.

2. *What is their potential to replace other less renewable resources, and to pay their way, in the long-term? Can this be enhanced, eg by genetic modification of plants or plant viruses or by advances in processing technologies? Can problems of consistency and reliability be overcome?*

There is good potential to replace a small volume of mineral oil in cutting fluid and chain saw applications due to technical advantages of oilseed rape oil. The advantages in a small sub sector of the metal cutting market provide good economic benefits to the end user. Less so in chain saw applications, and even less with hydraulic oil.

3. *What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?*

Whilst Mobil have carried out studies on life cycle analysis of oilseed rape in terms of overall environmental impact, we suggest the current work by Marcelle McManus at the University of Bath on this very subject may be more applicable to the United Kingdom.

BACKGROUND INFORMATION

Oil seed rape as a lubricant.

Main industrial uses of oilseed rape oil developed to date:

— hydraulic oil;
— cutter bar (chain saw) lubricant;

— specialist metal cutting oil (machine shops); and
— base oil for tunnelling equipment grease.

Hydraulic oil

Hydraulic oil applications for oilseed rape originally looked promising and high volume, but:

— in the United Kingdom there is little incentive to utilise lubricants whose soil or water course damage can be reduced by using low bio-toxicity lubricants;
— the concept of total life cycle accounting is not a common practice (cost of repair to environment of a major leak), whether this is for golf course maintenance, fisheries etc;
— an oil leak is a prosecutable offence, use of an oil of low bio-toxicity is a defence of last resort by showing due diligence. The fine is the same;
— trials showed rapeseed oil a better lubricant than originally thought;
— trials showed it lasted longer than originally feared and that bio degradation of the oil was not a significant factor;
— changing existing equipment from a mineral oil never achieves a 100 per cent rapeseed filling, despite several flushes, so the final rating of bio-toxicity is always worse than for a neat oil due to remains of the original charge. (This is specially important if the original oil was an engine oil whose additives are toxic in the unused state.). This means that "green" equipment must be built from new using low bio-toxicity oils at all stages to warrant a certificate of low environmental impact. This can lead to problems in manufacture and storage prior to sale if the oil used has finite life and storage concerns, such as with oilseed rape;
— bio-toxicity ratings refer to unused hydraulic oil. Used oil will be contaminated with wear metals so its effect on the environment is not definable;
— cold weather characteristics of rapeseed oil add to difficulties in use and storage. (There is a time + temperature effect that causes a reversible gross thickening of the oil below approximately minus 15°C if held there long enough). This can be overcome by attention to storage conditions of equipment and oil;
— high temperature characteristics lead to oxidation above sump temperature of approximately 80°C;
— the tendency of modern European and Japanese hydraulic equipment is towards compact, hard worked designs. Equipment that has temperatures above 80°C; and
— whilst oilseed rape oils are miscible with mineral hydraulic oils, there can be problems with engine oils due the additive chemistry.

Low bio-toxicity oils based on synthetic esters overcome virtually all the above negative comments and are the preferred solution to hydraulic oil applications.

CUTTER BAR (CHAIN SAW) LUBRICANT

Oilseed rape is an excellent material for this application. It performs roughly two times better than mineral oil in terms of life/amount needed/increased chain life. Regrettably it is more expensive and there is little incentive to use it in the United Kingdom except from contractual pressure by environmentally conscious organisations, land owners, local councils or Government bodies. (In fact this "third party" pressure effectively covers a large proportion of end users and is a recent and welcomed trend):

— the volume of oilseed rape based chain saw oils could replace the entire chain saw mineral oil market. (As is the case by legislation in Scandinavia.);
— in the United Kingdom there is little direct Governmental incentive to reduce long term soil or water course damage by use of low bio-toxicity lubricants;
— there is however a growing market awareness, Government agency and local Government pressure to use low bio-toxicity lubricants where possible;
— the concept of total life cycle accounting is not common practice (cost of replacing/maintaining chain saws, including labour being included in the cost of the lubricant). Therefore the additional chain life is not considered as a factor (for the opposite view see the cutting fluid application);
— the oil thrown off a chain saw is not regarded in the United Kingdom as an oil leak so there is no incentive to avoid prosecution for causing pollution by use of an oil of low bio-toxicity;
— rapeseed oil is a better lubricant than originally thought. It out performs mineral chain saw lubricant roughly by a factor of 2 to 1;
— roughly half the quantity is needed;
— chain saw oil is a total loss application so change over is not a problem;

— same comments on cold weather characteristics of rapeseed oil apply, but can be overcome by attention to storage conditions of equipment and oil; and

— price driven buying practice may not consider environmental or efficiency of use concerns.

Metal Cutting Applications

Oilseed rape oil has been utilised for some metal cutting areas, especially aluminium. In these areas the lubricant is excellent, it does however require special application equipment and can only be used successfully in some set-ups:

— the volume of oilseed rape based cutting fluids would not replace a significant part of the total cutting fluid market, even if fully developed;

— potential water course pollution is significantly less as much less fluid is used and what remains on the removed metal has low bio-toxicity;

— the concept of total life cycle accounting is a common practice with metal cutting, with the tool life and cost being carefully monitored;

— metal removal rates can be increased with improved surface finish;

— replacement of a water/oil cutting fluid by rapeseed oil eliminates biodegredation of the aqueous fluid, significantly increasing the machine availability; and

— cold weather characteristics or rapeseed oil are not significant as the application is indoors.

Special Grease for Tunnel Boring Machines

This lubricates the outer surface of a boring machine in direct contact with the ground. There is an occasional demand for high volumes of a low aquatic toxicity grease for which oilseed rape is ideal.

— oilseed rape based tunnel boring grease could replace all tunnel boring machine applications; and

— in the United Kingdom there is little incentive to utilise lubricants whose long term soil or water course damage can be reduced by using low bio-toxicity lubricants.

John Southey
Chief Engineer, Mobil Marketing

23 April 1999

Memorandum by the Natural Environment Research Council

Introduction

1. The Natural Environment Research Council (NERC) is the lead United Kingdom-wide organisation for basic, strategic and applied research and training across the spectrum of the environmental sciences. NERC's purpose is to support scientific research, survey and monitoring at universities and through its own Centres and Surveys: the British Antarctic Survey (BAS), the British Geological Survey (BGS), the Centre for Coastal and Marine Sciences (CCMS), the Centre for Ecology and Hydrology (CEH) and the Southampton Oceanography Centre (SOC—a joint venture with the University of Southampton).

2. Research related to non-food crops is both undertaken at institutes within CEH and supported by NERC at universities. NERC's research experience is mainly concerned with the environmental aspects of wood energy crops and their enhanced value through genetic modification. This response draws on input provided by the Institute of Virology and Environmental Microbiology (IVEM), the Institute of Terrestrial Ecology (ITE) and the Institute of Hydrology (IH) which are all part of CEH.

3. Our evidence is structured around the first three questions which deal with the potential development of non-food crops (including genetic modification) and their ecological impact.

Q1. *What is the potential for the development of non-food crops in the United Kingdom? Which crops, if any, are likely to prove significant in terms of economic activity or land use?*

4. If dramatic and possibly unacceptable change in the appearance of the farmed countryside environment is to be avoided, then only a small part of the current set-aside acreage could realistically be planted with non-food crops. None of the most realistic non-food crops have much economic prospect on marginal land at high altitude or on thin soils (although many "white" poplar genotypes tolerate low temperatures). Also, harvesting is easier when the land is flat.

Wood for Energy Production

5. ITE was involved in collaborative projects (with the Energy Technology Support Unit (ETSU))* in the early 1980s aimed at estimating the amount of land in the United Kingdom suitable for energy wood production—including short term coppice and modified conventional forestry. The study assumed that the better agricultural land would be converted to wood energy plantations and the poor land converted to modified conventional forestry. It was estimated that 35 per cent of the United Kingdom was technically and economically suitable for wood energy production, in the absence of any institutional constraint (for example, National Parks, Nature Reserves, Sites of Special Scientific Interest). This proportion dropped to 18 per cent when constraints were applied. At the time of the study, it was estimated that 20 per cent of the United Kingdom (4.6 million hectares) would have a "superior financial" performance, compared to the alternative land uses, under wood energy crops, a proportion that drops to 8 per cent (1.9 million hectares) when all social and institutional constraints are applied. This figure may well be even lower today as market prices for wood fuel have been forced down by reductions in prices of other fuels, such as oil and gas. The 1.9 million hectares was calculated as giving timber yields of 10.8 million cubic metres and 16 million dry tonnes of wood for conversion to four million tonnes of gas (with the then available technology), equivalent to 10–15 per cent of national gas consumption in the late 1970s.

6. Poplars and willows are front runners in terms of potential land use but "woody" grasses may also have a realistic place for biomass, particularly in southern Britain. Some poplar genotypes will tolerate drier conditions than most willow types, but both trees generally grow best in deep alluvial soils in river valleys. On a farm, poplars and willows grown in three to five year rotation can be used for shelter, as temporary refuges for wildlife (biodiversity above and below ground), for fuel (crucially requiring appropriate burners nearby) and for woodchips with additional value to the veneer-based furniture industries.

Alternative Crops

7. ITE undertook a study with the University of Reading* in the mid-1980s to assess the potential for alternative crops for United Kingdom agriculture. To define areas suitable for the production of alternative crops, the study combined information on the environmental requirements of a range of alternative crops with the data held in the ITE Land Class databases. The non-food crops considered were flax, lupin, sunflower and sea buckthorn. The study estimated that the following areas were suitable/available for the crops in the United Kingdom:

Flax 1.06 million hectares

Lupin 2.34 million hectares

Sunflower 1.17 million hectares

Sea buckthorn 1.38 million hectares

Significant areas of the lowlands, mainly under arable agriculture at present, were suggested as suitable for flax, lupin and sunflower. Relatively small pockets of land were suggested as suitable for sea buckthorn, some in coastal areas and some in the marginal uplands. The study also quantified the three current uses/dominant crops of the areas defined as most suitable for each of the alternative crops:

(i) Flax—30 per cent of the suitable land was then under wheat, 25 per cent under barley and 14 per cent under perennial ryegrass ley;

(ii) Lupin—17 per cent under perennial ryegrass ley, 16 per cent under mixed permanent pasture, 12 per cent under neglected pasture;

(iii) Sunflower—24 per cent under barley, 22 per cent under perennial ryegrass ley, 10 per cent under wheat;

(iv) Sea buckthorn—36 per cent under barley, 8 per cent under mixed permanent pasture, 6 per cent under beans and peas.

8. In an arable farm setting, the woody grasses may have limited uses but have one advantage over the tree crops in being less demanding of costly, specialised harvesting machinery and possibly the fencing to exclude rabbits that contributes very substantially to the establishment cost with the trees.

9. There are small niche markets for non-food crops grown with dual purpose usage (eg cannabis) or for:

(i) essential oils of value to the food chain (eg mint);

(ii) perfumery (eg rose, lavender); or

(iii) medicinal purposes either for the burgeoning, but traditional, herbal medicine markets (e.g. ginseng) or for more sophisticated and regulated pharmaceutical use. There are strict purity criteria for pharmaceutical medicines for human use, and it is unclear if these can be satisfied for field-grown crops. The veterinary markets may have lesser criteria for purity.

* More detailed results are classified as commercial in confidence and therefore are not included in this memorandum.

Q2. *What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg by genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability by overcome?*

10. In the current climate of relatively low mineral oil prices, biodiesel oil production is not economically viable but, as with flax and rape seed, "support" could determine the market viability. Agenda 2000 imposes a strong constraint but, if current intervention and the Common Agricultural Policy change, then the economic justification for conversion from short-term traditional arable farm crops to medium-to long-term commitment to poplars/willows would be different.

GENETIC MODIFICATION

11. There is considerable potential for poplars, and probably willows, to be given enhanced value through genetic modification.

12. Poplars and willows can be infected both experimentally and naturally with a diverse range of viruses with the potential for gene delivery. Poplar mosaic carlavirus, which has been completely sequenced in IVEM, is particularly suitable for gene delivery into willow and poplar.

13. There may be scope for use of virus coat protein modification (sometimes described as "overcoat technology") to deliver medicinal properties to plants.

14. Agrobacterium-based gene delivery systems have been used successfully for a few "white" poplar hybrids. Very few of the available hybrid "black" poplar clones have proved to be amenable to regeneration after genetic modification. Attempts at regeneration have focussed on poplar genotypes selected for use in traditional forestry systems, for rotary veneer or round wood. The United Kingdom is now weaker in the relevant technology than France, Belgium and Italy in Europe. North America and The Peoples Republic of China are relatively strong.

15. Genetic modification of poplars, achieved by ballistic means, has been used for a variety of purposes, including the enhancement of herbicide resistance, the modification of pest/pathogen damage, and changes in the features of the trees. Tree genotypes selected coppicing and frequent harvesting may well grow differently, from those selected for single stem forestry, after genetic modification. Extremely few poplar and willow clones have been assessed as candidates for genetic modification, and only a few are known to be amenable.

16. The present economic climate does not provide sufficiently strong incentives for new advances in fibre-based paper technologies. Grasses, for example, are resistant to genetic modification and subsequent regeneration, although experience with food suggests that, with appropriate resources, this can be overcome.

17. Problems of consistency and reliability of the products of genetic modification are likely to be surmountable as techniques improve, although there are still many challenges.

Q3. *What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?*

18. Environmental impacts of non-food crops arise primarily from changes in farm management practices. There is the potential for more intensive crop management that reduce biodiversity and for increased use of fertilisers and pesticides which could reduce soil and water quality.

19. Nevertheless, with careful management there are potential ecological gains. For example, greater diversification of crops and increased coppice woodland would produce wildlife benefits. As well as providing habitats for a wide range of wildlife, other known benefits of short rotation coppice (SRC) include low inputs of fertilisers and pesticides and the possibility of applying sewage sludge.

20. The economic justification for short rotation biomass crops is greatly strengthened when there are exploitation facilities nearby, as transport costs are a critical component. Thus, there is likely to be a strong tendency for lumpy distribution of non-food crops and scope for substantial visual impact in a few localities. Short rotation shrubs over large areas of lowland Britain may be unacceptable, even on an industrial agricultural landscape. Such crops may be uniform in colour and texture and considered unattractive, as were conifer plantations before plantations were mixed and boundaries deliberately softened.

21. IH has undertaken research work to determine the impact of SRC on water resources in the United Kingdom. The study found that poplar had higher water use than all the major agricultural crops and broad-leaved trees and came second only to pine forest. Extensive plantations would result in reduced stream flows and reduced peak flows and, consequently, the study concluded that:

(i) extensive plantation of SRC should be located in the wettest parts of the country where high water consumption of SRC will not have potentially serious consequences for water resources;

(ii) in drier areas, only a small proportion of a catchment should be planted; and

(iii) staggered harvesting could be used to mitigate increases in recharge and runoff resulting from shorter rotation periods.

22. The large scale planting of SRC could also have a significant impact on the quality of surface water and groundwater through its effect on the uptake of nutrients, especially nitrogen and associated nitrate leaching. This is of particular concern in areas of low rainfall, for instance eastern England. The possible impact of on water quality is less clear here although the extent of nitrate leaching is again likely to be a key issue.

23. Manipulative short-term experiments can inform Life-Cycle Analysis. Energy cost/benefit analyses are also possible; indeed, some cost benefit analyses have been done to judge the efficiency of traditional sources versus bio-diesel/ethanol crops.

Dr D W Lynn
Director, Planning and Communications

31 March 1999

Memorandum by NFU (the National Farmers' Union of England and Wales)

EXECUTIVE SUMMARY

We believe that by increasing the use of renewable raw materials, industry can help to reduce the consumption of finite resources of mineral origin and benefit the environment in a number of ways including reducing greenhouse gas emissions. For this to be achieved we believe that a robust, stand alone non-food crops framework should be introduced under the Common Agricultural Policy. This would take away the dependency of this industry on policies such as set-aside and the Woodland Grant Scheme, which were never specifically intended to encourage the non-food crops sector, and give farmers more confidence to invest in long term alternatives to food production. So far the sector has developed on a raft of imperfect mechanisms that were not designed to achieve what the non-food crops sector has accomplished. A targeted framework would stimulate investment into research and development and production in the non-food crops sector and help to realise the potential while at the same time reducing the quantities of surplus food production.

1. *Introduction*

1.1 The NFU is pleased to have the opportunity to submit written evidence to the House of Lords Science & Technology Sub-Committee non-food crops equiry. The NFU have been working for many years to try to encourage this sector. In doing so we have propagated the following organisations which focus entirely on non-food crops:

— ACTIN Alternative Crops Technology Interaction Network;
— ERMA European Renewable Raw Materials Association; and
— IENICA Interactive Network for Industrial Crops and their Applications.

1.2 Our written evidence follows a format which aims to answer the questions asked by Science & Technology Sub-Committee I in the non-food crops call for evidence.

2. *What is the potential for the development of non-food crops in the United Kingdom?*

2.1 The potential for the development of non-food crops as oleochemicals, fibres, pharmaceuticals and renewable energy is vast. To give one example, the European Commission White Paper *"Energy for the Future, Renewable Sources of Energy"* estimates that European Union renewable energy targets will require 6.3 million hectares to be planted with (solid fuel) energy crops by 2010 (for comparison the total European Union oilseeds area is 5.5 million hectares).

2.2 Policies which encourage the development of non-food crops are essential because the development of this important sector to date has been almost wholly dependant on the policies developed for another commodity sector ie the level of set-aside in the arable crops sector.

3. *Which crops are likely to prove significant in terms of economic activity or land use?*

3.1 There are numerous crops which are being developed for a multitude of non-food uses in the United Kingdom. While elsewhere in Europe varying Government incentives have led to differing developments eg liquid biofuels in France, the non-food crop which currently shows most potential in the United Kingdom is Short Rotation Coppice (SRC) for energy.

3.2 This crop has had encouragement through the Non-Fossil Fuel Obligation (NFFO) which is administered by the DTI. Eleven contracts were awarded under NFFO rounds three and four for projects which will use SRC as a feedstock to generate electricity. United Kingdom farmers have been reluctant to commit themselves to large-scale SRC production until they are sure that the market for the energy crop will be established and have an indication of the financial viability of growing non-food crops as opposed to food crops. However, farmers in one region of Yorkshire are beginning to have enough confidence to plant SRC

to provide a renewable feedstock for Project ARBRE; the first wood fuelled power station to be built in the United Kingdom. This is because the power station is scheduled to begin generation in November 1999.

3.3 Several other wood fuelled power stations are due to be developed in the United Kingdom under NFFO over the next few years. Some will be located on the western side of the country; where the main land use is currently grassland for livestock. Livestock producers would welcome the opportunity to diversify into the production of biomass. But if this is to be achieved, properly tailored support arrangements are required that recognise the substantial initial investment required and the lack of cashflow for the initial four year period.

4. *What is their potential to replace other less renewable resources and to pay their way, in the long term?*

4.1 Non-food crops will make a strong contribution to the objective of sustainable development by creating employment and revenue opportunities in rural locations and by providing obvious environmental benefits (ie by reducing greenhouse gas emissions and increasing biodiversity in the rural landscape).

4.2 Presently the failure of the market to internalise the full social costs and benefits of various methods of energy production and consumption make it difficult for non-food crops to pay their way in a strict accounting sense. However, we do believe that the public investment and support required would be more than justified by the environmental and soical benefits accruing.

4.3 In the medium term breeding programmes should make available to United Kingdom farmers a wide portfolio of crops for energy and renewable raw material use at economically competitive rates while maintaining environmental benefits.

5. *Can this be enhanced eg by Genetic Modification of Plant or Plant Viruses, or by Advances in Processing Technologies?*

5.1 Already we have seen the efficiency of non-food crops has been enhanced through improvements in processing technologies and breeding. The United Kingdom Industrial Crops Action Group[1] have stated that "over the past 10 years there has been considerable public funding, coupled with private funding (running into millions of ECU) of projects which have improved the economic and environmental performance of non-food crops and their derivatives". Given the correct operating environment, there is considerable potential for this to continue.

5.2 Unfortunately, since the future of non-food crops has been in jeopardy pending the outcome of Agenda 2000, some processors have threatened to reduce their funds for research and advances in technology. It is clear that the sector requires sustained funding for research and development from both the public and private sector.

5.3 Research at institutes such as the John Innes Centre in Norwich has shown that crops can be modified and enhanced to substantially better their application as renewable raw materials.

6. *Can Problems of Consistency and Reliability be Overcome?*

6.1 Yes. As with all crops, we are sure that, given enhanced breeding materials and experience in producing non-food crops, farmers can combat the problems of consistency and reliability. The fluctuating supplies of non-food crops have been a direct result of fluctuating set-aside levels.

7. *What are the Environmental and Ecological Implications of the Development of Non-Food Crops?*

7.1 Crop derived raw materials can provide power without net emissions of carbon dioxide; reduce fossil fuel consumption by displacing existing fossil fuel uses; provide biodiversity in the landscape and importantly, in a wider context have the potential to retain or create employment in rural areas.

7.2 The ecological implications of the development of energy crops have been studied by MAFF and the DTI through projects managed by ETSU. The Game Conservancy has recently published a booklet *"Integrated pest management in short rotation coppice for energy—a grower's guide"* which gives a brief outline of the beneficial ecological implications of SRC production for plants, insects, and birds (page 24). The NFU has also helped to produce the industry *"Good practice guidelines: Short Rotation Coppice for energy production"*. The ecological implications of SRC production are outlined within the booklet (particularly page 18). Both booklets have been submitted with this text. [*not printed*]

[1] The United Kingdom Industrial Crops Action Group includes representatives of breeders, growers, traders and consumers of non-food crops. Members include: The Seed Crushers and Oil Processors Association (SCOPA), The National Farmers' Union (NFU), The Alternative Crop Technology Interaction Network (ACTIN), The Home Grown Cereals Authority (HGCA), The British Society of Plant Breeders (BSPB), and The United Kingdom Agricultural Supply Trade Association (non-food crops committee) United KingdomASTA.

7.3 The conclusions of Life-Cycle Analysis would be extremely helpful in lobbying for a support structure for the non-food crops sector. We believe that such analysis would highlight the environmental benefits that would amass from further utilisation of crop derived raw materials by industry.

8. *Are there Regulatory Barriers to the Development of Non-Food Crops, or Disincentives in the Current System of Taxation and Subsidies?*

8.1 Although NFFO has helped to stimulate the development of some large scale energy crop markets, the NFU believes that it is currently an imperfect mechanism for the encouragement of the small scale market.

8.2 We believe that, to encourage the development of biomass power generation, the next round of the Non Fossil Fuel Obligation (NFFO) should have a transparent bidding process which would enable smaller scale developers to bid on an equal footing with larger scale developers. The present mechanism is particularly difficult for potential developers of small projects who have trouble coping with the uncertainties of a blind bidding system.

8.3 NFFO is targeted towards large scale projects which generate electricity for the national grid. We believe that the greatest potential for the development of renewable energy lies in local industrial and domestic heating and combined heat and power (LHP—technology. We have been led to believe that the next NFFO round (NFFO–5b) will be targeted at biomass (rather than traditional technologies such as nuclear power) and will be announced in early 1999. We urge the Government to announce its intentions for NFFO–5b as soon as possible and to ensure that the bidding process does not discriminate against smaller scale projects.

8.4 We are concerned that several of the biomass projects which have NFFO contracts are facing difficulties obtaining planning permission. It is important that the Government produces clear planning policy guidance on this subject for planning officers.

8.5 We are concerned that restrictions on the use of technology which facilitates genetic modification may create another barrier for the future development of non-food crops. It is possible to modify and enhance the application of non-food crops by creating "tailor-made" characteristics.

8.6 The current taxation system does not create an incentive for industry to use renewable materials. Creating tax incentives to use renewable materials, ie liquid bio-fuels, would help to encourage the utilisation of crop derived raw materials.

8.7 Although growers, processors and consumers are now realising the environmental benefits of non-food crops, there is little doubt that the key driver for the growth the sector has been set-aside. However, we believe that this dependency on set-aside has also hindered the development of non-food crops for the following reasons:

- uncertainties over the future of set-aside policy have reduced growers confidence in the economic viability of growing multiannual biomass crops; and
- only those non-food crops which appear in Appendix 1 of the Intervention Board booklet (IM(C)41) can receive arable area payments through set-aside. This restrictive list is hampering the development of crops such as calendula.

8.8 The NFU urge that the Commission help to combat these impediments by introducing:

- a mechanism which will give farmers confidence to establish long term multiannual biomass crops such as SRC;
- flexibility into the crop types which can be grown on set-aside (ie appendix 1 of the Intervention Board Booklet) and thus receive payments that are equal to those received by farmers growing food crops; and
- a provision for annual payments for non-food crops on land which is not eligible to be set-aside under the arable area payments scheme.

8.9 During their discussions on Agenda 2000 the European Union Agriculture Council asked DGVI (the directorate responsible for agricultural policy) to write a report on non-food crops in the context of Agenda 2000. The NFU is disappointed that DGVI did not take this opportunity to properly review or make strategic policy recommendations for the non-food sector. Instead, DGVI produced a working document reviewing the current situation which makes no new recommendations.

8.10 It is essential that a rigorous report is produced which examines how the long term potential can be developed and harnessed. If DGVI cannot do this, then the potential for an independent body to carry out the work should be investigated.

8.11 The NFU is pleased that the European Union Agriculture Council has stated its intention to encourage the development of non-food crop production within the rural development regulations of CAP reform. Clearly we must now work with MAFF and the European Commission to ensure that this intention is realised.

9. *Are the Local, National and European Union Regulatory Regimes Appropriate?*

9.1 There is no regime for non-food crops. The only nationally administered scheme which aids the development of non-food crop production is the Woodland Grant Scheme (WGS). Under European Common regulation 2080/92 member states can award grants for the establishment of multiannual biomass which are equivalent to up to 50 per cent of the establishment costs. In the United Kingdom this regulation is only implemented within a 40 mile radius of Project ARBRE, where grants of £1,000/ha are available. We believe that this level of grant should be available nationally. We also believe that the grants should not be administered through the WGS as this limits the grants to woody species, ie, willow and poplar. The development of other, non-woody energy crops such as miscanthus should not be hindered by this technicality.

9.2 It appears that a number of pragmatic changes have been introduced into the WGS under Agenda 2000 that will help in the short term, however they will not unlock the full potential in the long term.

9.3 The NFU strongly believe that a robust, stand alone non-food crops framework should be introduced under the Common Agricultural Policy. This would take away the dependency of this industry on policies such as set-aside and the WGS which were not intended to encourage the non-food crops sector. A targeted framework would stimulate investment into research and development and production in the non-food crops sector.

9.4 On a national level we believe that an accompanying policy should be introduced to encourage market development for non-food crops, in particular:

— for energy crops by stimulating domestic and small-scale industrial heating systems as well as large-scale generation; and

— for other non-food crops by exploring industrial opportunities for renewable raw materials.

9.5 Both heat and combined heat and power installations give efficient utilisation of energy crops. We believe there is great potential to develop small scale heat and power markets, which could help farmers to reduce their dependency on traditional markets. Local, small-scale markets for energy crops could provide farmers with the opportunity to market, process and deliver crops (and possibly heat and electricity) directly to the consumer. Small scale CHP plants and heating equipment should be encouraged by Government grant schemes. Capital incentives could be offered to domestic and small scale industrial consumers to install biomass based heating systems.

9.6 We are concerned that regulatory regimes could be introduced which will hamper the development of renewable raw materials such as biodegradable plastics. We refer specifically to regulations which may prohibit the use of genetically manipulated crops.

10. *Is the Level and Direction of the United Kingdom and European Union Public Funding for Research and Development Appropriate?*

10.1 We welcome the emphasis that has been placed on research for non-food crops over the past five years but believe that more funds should be made available for research and development in all aspects of non-food crop production, harvesting and storage.

11. *Summary Recommendations*

11.1 The NFU strongly believes that the United Kingdom Government should:

— ensure that NFFO is more targeted at biomass and that it encourages both large-scale and small-scale generation projects;

— announce NFF0-5b as soon as possible;

— urgently issue clear planning policy guidance on renewable energy projects for planning officers;

— introduce a policy to encourage the creation of new markets for energy crops, in particular by stimulating domestic and small-scale industrial heating systems as well as large-scale generation; and

— encourage sustained funding from both the public and private sector for research and development into all renewable raw materials.

11.2 The NFU strongly believes that the European Commission should:

— introduce a robust, stand alone non-food crops framework under the Common Agricultural Policy;

— introduce a facility to enable farmers to commit to mulitannual biomass crops;

— introduce flexibility into the crop types which can be grown on set-aside;

— provide an annual subsidy for the production of crop derived raw materials on non-eligible land;

— commission an independent body to make a study of non-food crops in the context of agricultural policy; and

— encourage sustained research and development funding from both the public and private sector.

March 1999

Memorandum by the Royal Botanic Gardens Kew

1. *Medicinal and aromatic plants.* The United Kingdom imports 6,750t/year with a value of $24 million (Lange, 1998). Many are wild collected from other European countries and 150 species are reported to be threatened as a result in at least one of them. The sustainability of their supply is questionable. Given the rapidly increasing market for such species in alternative and herbal medicine (and cosmetics), it would be worth investigating which ones could be cultivated commercially in the United Kingdom.

2. *Potential for biomass.* For *miscanthus*, see submission from ADAS.

3. *Environmental and ecological considerations.* The growing and exploitation of native species (eg common reed *phragmites communis* for thatch and industrial efluent treatment; willow *Salix* spp as SRC) would benefit wildlife, and help retain aspects of traditional landscape, management skills and associated rural employment.

4. No comment.

5. No comment.

REFERENCE

Lange D 1998. *Europe's medicinal and aromatic plants: their use, trade and conservation.* TRAFFIC International. 77 pp, plus appendices.

April 1999

Memorandum by the Royal Society

INTRODUCTION

The Royal Society welcomes the opportunity to give its views on non-food crops. The Society believes that non-food (industrial) crops are of great importance: it will continue to be active in providing advice to Government and others on this subject.

The Society would like to draw attention to the following pubications which are of relevance to this inquiry: *Genetically Modified Plants for Food Use* (Royal Society Statement 1/98) and *The Regulation of Biotechnology in the United Kingdom* (Royal Society Statement 3/99). (*not printed*)

This response has been endorsed by the Council of the Society. It was prepared by a group chaired by Professor P Bateson (Biological Secretary and Vice President of the Royal Society), and comprising Professor M Gale, Professor C Leaver, Dr G Lomonossoff, Dr J Ma, Mr J Macleod, Professor A Slabas, Professor A Smith and Dr S Lipworth (Secretary).

The main points made by the Society in this response are as follows:

— non-food crops have significant potential to make an impact both on land use and economic activity, particularly those intended for use in energy production or as sources for fibres in biocomposites;

— non-food crops used for the production of speciality chemicals, notably pharmaceuticals, are also likely to become increasingly economically viable, although this will depend on quality and the development of new processing techniques;

— the use of genetic modification techniques inceases the number of potential applications for non-food crops. However, it is important to address potential environmental concerns during the development of such crops (see Statement on *GM plants for food use*); and

— few incentives, either from taxation or subsidies, promote long-term development of potentially important non-food crops. We recommend increased co-ordination and availability of research funding in order to take advantage of a rapidly developing area.

1. *What is the Potential for the Development of Non-Food Crops in the United Kingdom? Which Crops, if any, are Likely to Prove Significant in Terms of Economic Activity or Land Use?*

The potential for non-food crops in the United Kingdom is significant. However, the further development of non-food crops will depend on the demand for new products and processes derived from them. This demand is difficult to predict because a full understanding of the actual and potential applications, benefits and drawbacks of materials derived from non-food crops over traditional crops is still uncertain.

A useful approach to understanding the potential of non-food crops is to consider their potential end uses. These include:

- renewable energy crops eg biomass grown for conversion to energy (eg willow) and biofuel (biodiesel and bioethanol) which can replace fossil fuels and mineral oils;
- bulk chemicals, mainly oils derived from linseed, oilseed rape and sunflowers;
- speciality chemicals such as pharmaceuticals, cosmetics and dyes; and
- speciality biocomposites such as biologically derived fibres (mainly derived from hemp and flax); lignocellulosic glues, dispersants, fertilisers, and additives; bioplastics, paper and board such as those derived from starches.

At present the most important non-food crops in the United Kingdom are linseed and oilseed rape.

Energy crops

While a large variety of crops might be used in any of the product groups listed above, the most significant non-food crops in terms of economic activity or land use are likely to be biomass non-food crops used in energy production. These include willow, poplar, and hemp.

Biocomposites

The interest in fibre crops and production, most notably flax, for use in construction composites (eg fibreglass alternatives) is substantial and increasing.

Almost all of the starch used by United Kingdom industry is imported, in the form of maize grain and starch (60 per cent of United Kingdom industrial starch use is maize starch) and potato starch (30 per cent of United Kingdom industrial starch use). Most or all of our requirements (approximately 200,000 tonnes pa) could be grown in the United Kingdom as wheat and potato with possible contributions from barley, oats, rye and quinoa. Starch is an essential component of paper cardboard and related products, and is used widely in the manufacture of glues, pastes, paints, cosmetics, detergents, pharmaceuticals, and biodegradable plastics, and as an anti-sticking agent in, for example, plastic gloves and various sorts of moulds.

Speciality chemicals

The production of speciality chemicals from non-food crops is not expected to prove significant in terms of land-use however this too could change, for example if the potential for the use in the United Kingdom of plants as bioreactors is developed.

Genetically modified (GM) crops have potential for development in the United Kingdom. Recently, the emphasis has been on GM foods, but it is likely that more favourable public acceptance may develop of GM technology may develop from GM modifications that lead to new pharmaceuticals and other medical products, as well as raw materials for energy and plastics. The cost of production of pharmaceuticals in plants is likely to be far less than the cost of producing equivalent materials using fermenter (traditional manufacturing) technology. Given the huge biomass that can be produced from plants, it is quite possible that using plants in this way could result in the practical development of novel pharmaceuticals (eg vaccines) which are too expensive to produce conventionally.

In both the European Union and United States of America the interest in this type of technology is great. In 1998, the first two human clinical trials with vaccines derived from GM plants were reported in the scientific literature[1]. At present, all the research is done on a small scale under containment conditions. In the United States, plant biotechnology companies have already acquired farms to develop into pharmaceutical production facilities, working under controlled conditions as laid out by the United States of America Food and Drug Administration.

Although the land requirement for GM crops may be relatively small for the production of high value pharmaceuticals, as the technology develops more ambitious projects may be undertaken to produce low cost medical products in bulk (for example, blood replacement products). In the area of GM protein production, agrobiotechnology can also be applied to non-medical areas such as industrial enzymes and these types of applications could involve significant demands on land.

Despite many potentially useful developments in non-food crops, in particular GM crops, concerns about wider ecological impacts and potential transfer of genes are considerable, as discussed in our statement *GM plants for food use.* It is important to address such concerns during the development of any non-food crop intended for future commercial use.

[1] 1998 Ma, J K-C, B Y Hikmat, K Wycoff, N D Vine, D Chargelegue, L Yu, M B Hein and T Lehner. Characterization of a recombinant plant monoclonal secretory antibody and preventive immunotherapy in humans. Nature Medicine.4:601-607.

2. *What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg by genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability be overcome?*

(a) *Replacement potential and economic viability*

Fossil fuels and petrochemicals

The use of alternative raw materials in order to supplement or eventually replace less renewable resources is essential in the longer term in order to replace dwindling supplies of materials such as fossil fuels. Non-food plants may provide an alternative source of such raw materials with generally lower environmental impacts than those associated with fossil fuels. At present these materials are not nearly as widely used as they could be, because their costs are relatively high, and because their quality in some cases is relatively poor. The potential of energy crops to replace less renewable resources such as fossil fuels and petrochemicals with those derived from renewable plant based materials is complicated by socio-economic issues, for example the trade-offs between sustainable environmental benefits and short-term economic factors such as what people are prepared to pay. It is likely that socio-economic considerations will play an important role in determining the demand for renewable resources such as biodiesel. These issues make it difficult to base decisions on current cost comparisons alone.

The potential is, however, high for the development of new biomass crops and central to much of this will be developments in the genetic modification of plants. The potential for these crops to replace other, less renewable resources, will also depend on the presence of the proper infrastructure and mechanisms such as facilities that convert biomass to electrical power eg wood-fired power stations. It may also be possible to realise considerable short-term returns on investment in biomass crops such as poplar, willow and hemp.

Starch and oil from plants may replace many current uses of petrochemicals. Starch has great potential to replace petrochemical feedstocks (raw materials) in some aspects of the plastics and paint industries. Its advantage over petrochemicals is that it is a renewable and vastly abundant resource. Furthermore, its use does not make a net contribution to atmospheric CO_2, and products made from it are biodegradable. Several research groups and industries are trying to produce starch-based plastics with desirable combinations of resistance to moisture and biodegradability for a wide variety of applications. It is possible to buy, for example, microwave dishes, golf tees, ground-stabilising nets, pen casings and packaging granules made of starch rather than petrochemicals, and the list is increasing all the time. However, plastics manufacture accounts for only about 3 per cent of the industrial use of starch in the United Kingdom.

Glucose or small oligosaccharides derived from starch are also being used increasingly as chemical feedstocks (raw materials) for the manufacture of detergents and components of paint, in place of feedstocks derived from petrochemicals. Starch is certainly not able to compete with petrochemicals for the plastics, surfactant and paint industries on purely economic terms at present. However, increases in the price of oil, the finite supply of this commodity, improvements in starch-based products and increasing consumer demand for "green" products would all favour starch over petrochemicals in future.

Speciality chemicals

Longer term returns will potentially be realised with "speciality" crops, such as those involved in the production of pharmaceuticals. The use of plants to produce pharmaceuticals is definitely seen as a way of replacing existing fermenters that are very expensive to develop and run. Novel processing technologies are likely to be necessary if the products are to be extracted and purified from the plants. However, in certain instances purification may not be necessary, for example in the development of "edible vaccines". The limiting factor in this case will be the development of crops that produce high quantities of the desired speciality product and development of means by which to rapidly and inexpensively extract the desired product.

(b) *Contribution of genetic modification and technological improvements*

There is no doubt that the application of genetic modification can dramatically enhance the utility of non-food crops. Genetic modification has numerous potential applications in the improvement of crops for non-food uses. It has contributed, for example, to:

- the production of new oils with valuable industrial properties by the introduction of single genes from wild species of plant into oilseed rape, reducing the use of petrochemically-derived oils;
- the modification of the structure of wood, to reduce the need for chemical treatment during pulping and thus reduce the enormous effluent problems of the paper industry; and
- the production in plants of antibodies or of components of viruses for use in vaccines, which can reduce the expense and increase the availability of treatment for serious diseases, and reduce the use of animals in medicine.

Other examples of the potential benefits of genetic modification can be found in starch crops where it can reduce the dependence on post-extraction modification procedures. Different end users require starches with different physical properties. To meet this demand, starch from maize or potato is modified by chemical,

enzymic or physical methods to produce a whole range of difference functionalities. These modifications are expensive and energy-consuming, and they generate polluting wastes. The production of GM cultivars of starch crops, each with a different complement of starch synthesising enzymes and hence producing starches with naturally different functionalities, should reduce the need for post-extraction modification. Genetic modification of starch synthesis may also result in plants which produce starches with novel functionalities—not thus far obtained through post-extraction processes. Such material may expand the industrial use of starch as a replacement for petrochemicals.

It is important to appreciate that there are plant species not currently grown as United Kingdom crops that naturally produce starches with functionalities quite different from those of maize and potato starch. The extent to which use of starch from such species, rather than genetic modification of existing starch crops, could reduce the need for post extraction modification and offer novel functionalities has not been fully explored. This would be a long-term goal as most of the species have poor agronomic potential in the United Kingdom. Genetic modification of starch synthesis is well advanced, and a transgenic potato cultivar containing a starch for industrial use has reached the final stages of the regulatory procedures required before commercial release in Europe.

GM plants producing pharmaceuticals show great potential. One example of plant product nearest to commercial realisation is a vaccine against tooth decay, and GM plants represent the only means available for production of this complicated vaccine. For other pharmaceuticals, non-food plants can offer a cheaper means of production compared with methods currently available. The most obvious reason for this is the potential agricultural scale on which drugs and vaccines could be produced and the financial benefits that will result. However there are other significant technical advantages that will benefit the pharmaceutical industry. One advantage is that there is a broad similarity between the biochemistry of plant and mammalian cells. This allows the production of molecules, some of which could be made without the use of costly mammalian cell cultures, or even experimental animals. A second advantage is that plants do not host any human pathogens such as viruses or prions, which makes their use for pharmaceutical production attractive on the grounds of safety.

Enhancement of processing technologies is an important development stage and indeed research in this area has been strongly supported by the European Union. A considerable research effort has been directed into improvements through genetic modification. These have been successful in areas such as improving disease resistance, enhancing fibre content and biomass for energy production as well as in modifying enzymatic pathways and developing new metabolic pathways in crops which can lead to products such as biodegradeable plastics, new starches, new oils.

This inquiry specifically excludes the traditional uses of tobacco, however, its usefulness in the field of genetic modification needs to be mentioned. Certain varieties of tobacco are currently the plant species of choice for genetic transformation for the production of recombinant proteins for pharmaceutical purposes. Tobacco has been studied for many years as a model plant, and much of the basic plant science has been carried out in this species. Tobacco is extremely easy to genetically modify, regenerate and grow. Although it is unlikely that tobacco will be grown in the field in the United Kingdom, its use under cover or in green houses is certainly an important option for producing high value medicines that are not subject to large demand. The overall characteristics of tobacco make it an important candidate in this area of protein production.

Although genetic modification has the potential to increase the scope of developments in non-food crops it is important that current environmental concerns are addressed by further research. Possible environmental impacts of GM crops were discussed at length in *GM crops for food use.* However, it is likely that the most significant concern for GM non-food crops will be the likelihood of gene transfer to other plants, in particular to food crops. If such transfer is likely to be detrimental then statutory isolation measures may be required.

(c) *Consistency and reliability*

Energy crops vs petrochemicals

Consistency and reliability are important factors when considering the potential of non-food crop products to replace less renewable resources. A more uniform and higher value crop could be achieved by traditional methods, as is currently the practice with biomass crops that are coppiced. Genetic modification could be used to enhance the desirable attributes of such crops.

While fossil fuel oil is available, industry may prefer tried and tested chemical processes to a novel process based on plant-derived materials. Firstly, plant-derived materials are often less homogeneous and less consistent between batches than oil derived from fossil fuels. More research is needed on the initial processing of plant material to yield "clean" products—for example the use of wheat starch would be boosted by better processes to separate it from protein during milling. Secondly, the manufacture of a product from plant polymers may require completely different conditions and equipment from those needed for oil-based processes: investment in research and equipment will be needed. Thirdly, if the most suitable plant product to replace a petrochemical product is from a specialised crop or a specific cultivar and is needed in relatively small amounts, manufacturers may feel that the supply could be unreliable. Innovative forward thinking and investment is required by industry if plant products are to be developed.

Speciality chemicals

Companies involved in the processing of speciality chemicals are likely to be multinational and therefore may not be solely reliant on single crops grown in the United Kingdom. For high value pharmaceuticals, the problem may be overcome by growing the crops under controlled (ie greenhouse) conditions.

With regard to starch based products there are two main concerns. Firstly, starch-based plastics are thus far of poorer quality than those made from petrochemicals. This may not be a problem for some products, and the consumer may well accept an environmentally friendly product of slightly inferior quality. Consumer education may be as important as further research in promoting the widespread use of starch plastics. Second, where starch is one of several components of a product, end-users are understandably reluctant to become dependent upon what may be a relatively small crop of GM line "designed" to produce starch of the correct functionality, in preference to a standard starch which has been modified after extraction to give the correct functionality. Modification after extraction gives a completely reliable source of material, whereas a crop failure of the "designed" cultivar could jeopardise an industrial process. There is however no reason to suppose that the stability of starch characters and the agronomic performance of GM starch crops will be poorer than those of conventional cultivars.

3. *What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?*

There are positive and negative aspects associated with the development of non-food crops. These will have to be evaluated on a case by case basis and generalisations should not be made. Non-food crops need to be evaluated by comparison with alternative methods of production. This can be done by Life-Cycle Assessments. Life-Cycle Assessment involves making comparisons of the environmental impacts at each stage of the production processes including the use of the products and their ultimate fate. This approach, is however, problematic due to the paucity of information upon which to base decisions and the inherent differences, nature and scope of plant based (agricultural) production compared with more conventional industrial processes.

Depending on the type of non-food crop, the environmental implications can be quite limited. For "native" non-food crops like poplar, willow and flax the impact is likely to be limited. In fact, it is conceivable that the impact of these crops might be less than that of food crops raised on the same land. Furthermore, non-food crops products can benefit the environment by requiring less herbicide inputs. Certain plant species, such as miscanthus (elephant grass) have the ability to extract metals from soils and can be used in the bioremediation of degraded environments. However, more information is needed as there may be some problems associated with biomass crops in that they may extract more water from the soil than traditional agricultural crops. Although there may be potential negative environmental and ecological implications associated with non-food crops these need to be contrasted and compared with those that are produced when making any changes to crops and farming practices.

Environmental assessments of impact are further complicated when considering the implications of GM plants compared with other naturally evolved systems. A particular concern of non-food industrial crops is the likelihood of crossing with wild relatives (Royal Society statement 1/99). Potential effects of non-food crops on the ecosystem should also be considered for both GM and non-GM plants. The use of GM-non-food crops to produce foreign proteins (such as antibodies) poses particular concerns with regard to possible gene exchange with wild relatives and other crops. It will be essential to minimise such gene transfer by isolation or by GM to prevent pollen production for example (Royal Society statement 1/99).

It is notable that in general, the recombinant proteins are produced in all parts of the plant. Therefore the plants can be harvested before maturation of any of the sexual organs which eliminates the risks associated with contamination of the environment by pollen or pollinating insects. It is also possible to use inducible promoters that allow production of the recombinant protein to be "switched on". This is a critical development which means that it may be possible to develop a pharmaceutical product that is not produced in the plant in the field, but only expressed post-harvest, once the biomass has been collected and stored.

GM non-food crops that are used in biomass production are likely to be relatively acceptable to the public since the modification is unlikely to have a detrimental impact on the environment, for example, GM resulting in enhanced energy content in trees for biomass production. Furthermore, the likelihood of "escape" of genes from GM plants (so-called "genetic pollution") is very low as the plant material is generally harvested before sexual reproduction takes place.

Assessments will need to be performed both on GM and non-GM material if we are to be fully aware of their environmental impacts. Assessments will need to be made of the relative impacts of harvesting and downstream processing of both GM and non-GM products. Such costs could include transport, pollution by emissions and by-product disposal.

4. *Are there regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?*

There is uncertainty surrounding the time required for approval of new crops in current European legislation, particularly when such crops are GM. This makes investment by industry very difficult to justify. The RS has urged the Government to press for short time-tabling and greater transparency following the revision of the legislation (Royal Society statement 3/99).

The use of plants to produce pharmaceutical products, such as vaccines, is a novel approach and the current regulatory regime may need adjustment to specifically deal with such products. Pharmaceuticals produced in plants would also have to be shown to as safe and efficacious as the equivalent product produced by more conventional means.

In starch production there are very strong regulatory barriers. There are European Union support payments on a quota basis to potato starch manufacturers. The United Kingdom does not have any of this quota, preventing the further development of a United Kingdom potato starch industry. Even if support were available, the growth of potatoes for starch would require a large shift in United Kingdom agricultural practice. The success of the Dutch potato starch industry comes from large-scale, intensive potato growing to supply large local processing plants. It would be possible to produce much of the United Kingdom starch requirement from home-grown wheat.[2] However the viability of a starch industry based on home-grown wheat would depend on the level of duty on cereal imports.

There are currently few incentives, either from taxation or subsidies, to promote the long term development of these crops. Although there have been several efforts to promote academic and strategic research into non-food crops through public funding in recent years, overall, though, funding has been rather piecemeal. At present there is a significant focus by the major research funding bodies on food crops. In as much as this makes research on non-food crops difficult, this is a disincentive in the development of these crops. We recommend increased funding for the development of non-food crops, from the relevant bodies such as MAFF and the Forestry Commission which should be made available to competitive tender.

5. *In the light of the above*

(a) *Are the current United Kingdom and European Union subsidies for non-food crops, and the proposals under Agenda 2000, appropriate*

In sharp contrast to the United Kingdom, the European Common has identified the production of non-food crops, such as biomass crops for energy, as a key target area for funding under the Framework V research funding programme. Accelerated uptake of non-food crops developed under this research programme would be achieved by appropriate subsidies. In certain countries in Europe these are available and biodiesel is a case in point. At present in the United Kingdom there is insufficient funding to promote development.

What are required are targets which can be concentrated on without changing the crop every few years. In this respect uncertainties of the Common Agricultural Policy (CAP) reform are not helping. CAP reforms introduced in 1992 were aimed at reducing food production across the European Union by taking a percentage of agricultural land out of food farming. The so-called set-aside land attracted subsidies for the growing of non-food crops. Proposed CAP reforms, currently under review in the light of European Union expansion, are set out in the European Common 1997 document Agenda 2000. If implemented these reforms could result in a decline in the production of non-food crops due to a reduction in subsidies.

(b) *Are the local, national and European Union regulatory regimes appropriate; and*

The United Kingdom, regulatory regime is appropriate, but also under review. However, regulatory regimes are not uniform across the European Union and this is not helping to promote non-food crops.

(c) *Is the level and direction of United Kingdom and European Union public funding for research and development appropriate?*

As indicated above, the direction and amount of funding for research in the United Kingdom is adequate. This is in sharp contrast to the European Union where the direction is focused, and the funding, appears to present to be significant. In the next round of Framework V, non-food crops has been highlighted for funding and will attract a high number of quality applications.

In the United Kingdom public funding for research into GM crops for medicinal purposes has been less well managed. This is partly due to the long-standing distinction between research proposals submitted to different funding bodies and the traditional emphasis of these funding sources. Effort needs to be directed at

[2] 1996 report Industrial Markets for United Kingdom Grown Plant Polysaccharides LINK programme on Crops for Industrial Use.

a few selected targets with longer time scales appropriate to this research. This can only occur if longer term funding (more than three years) of the programme is achieved. It needs to be recognised more clearly that this area of research is truly multi-disciplinary and requires expertise both from plant scientists as well as human and animal scientists. The interaction between appropriate parties needs to be maintained and in some instances initiated.

Although there is consumer interest in "environmentally friendly" products, this does not appear to be a more important consideration for most consumers at present than high quality and low cost. The cost of plant materials to industry is strongly related to agricultural and trade policy rather than the actual cost of production. The present quality of plant-based products is in part a reflection of the lack of research on such materials. This can be addressed by further research that will generate new and exciting ideas for the development and improvement of non-food crops. However, this will require financial incentives, longer term research funding, a level European regulatory framework and national strategy on the development of non-food crops.

Dr S R Lipworth

April 1999

Memorandum by the Royal Society of Edinburgh

On behalf of the General Secretary, Professor Peter Wilson, I enclose the Society's submission to the inquiry into non-food crops. The enclosed response has been compiled with the assistance of a number of Fellows with many years experience in agriculture and crop development.

One of the Fellows has queried some of the figures provided in Figure 1 of the POST note 125 relating to linseed and oilseed rape (OSR), provided by the Intervention Board, Alternative Crops Unit (MAFF), Agriculture in the United Kingdom 1996 and Agricultural and Horticultural Census 1998. He notes:

"Traditionally linseed contains a highly unsaturated oil rich in linolenic acid (triene) with industrial uses based mainly on the ease with which it is oxidised and polymerised (as in linoleum, paints, varnishes, etc.) There is now a different form of linseed (generally called linola) which is low in linolenic acid and rich in linoleic acid (diene). It has a composition very similar to that of sunflower seed oil and is used as an alternative to this oil in polyunsaturated spreads. This is clearly a food oil but in the statistics available to me the two forms of linseed are not distinguished. I do not expect that linola is yet a significant proportion of the linseed grown in the United Kingdom but considerable quantities are being grown in Canada. This is not a genetically modified seed but the product of chemical mutagenesis followed by conventional seed breeding.

The major form of OSR is the low erucic variety but the high erucic variety is also grown for oleochemical use. Does the 28kha of non-food rape refer to this material or is it a description of rape grown only on set-aside land whether this is high erucic or low erucic oil? The high erucic oil is grown only for oleochemical uses: the low erucic oil is grown mainly for food purposes but it can and is used for non-food purposes. These include biodiesel (RME or rape methyl esters), use as a lubricant, and as an epoxidised oil.

The production of these two oilseed crops in the United Kingdom is reported in Oil World Annual for 1998 at the following levels.

	97–98	*96–97*	*95–96*	*94–95*	*93–94*
Area (kha)					
Rape	472	414	439	496	421
Linseed	76	55	62	67	156
Oilseed (kt)					
Rape	1523	1410	1235	1254	1256
Linseed	106	86	81	78	180

I believe that these refer to all the varieties of both oils."

1. The Royal Society of Edinburgh is pleased to respond to the Select Committee's request for comments to its inquiry on non-food crops. The RSE is Scotland's premier learned society, comprising Fellows elected on the basis of their distinction, from the full range of academic disciplines, and from industry, commerce and the professions. This response had been compiled with the assistance of a number of Fellows with many years experience in agriculture, crop development, forestry and land-use.

2. There is considerable scope for the development of non-food crops in the United Kingdom, with a fairly wide range of crops and crop applications having potential. However, almost all crops and applications that have potential also have hurdles to overcome before their potential could be exploited commercially. Under the present commercial conditions the alternative crops (or crop derived products) do not offer sufficient cost benefits to justify the investment needed in the processing plant/industrial infrastructure necessary for the

development of the crop as a commercially viable alternative. Importantly, many of the economic analyses that operate to the detriment of the non-food crops are heavily influenced by the taxation or pricing policies that are dictated by the nature of present public policy or by the incomplete nature of the costing regimes that are applied. For example, there is often an incomplete accounting of environmental and other costs that lie outside the framework of a conventional economic analysis. The situation is complicated by the application of European Union incentives and subsidies to certain crops.

3. Many non-food crop developments also require an initial investment in processing plant. This is often impossible to justify commercially in a situation where there is uncertainty about the likely scale of the volume supply of the crop and uncertainty about the likely uptake of the non-food crop product in the market. Thus there is a chicken and egg situation in which the cycle can only be broken by a combination of public decision that will provide or facilitate investment in processing plant, and the willingness of a significant commercial company to take a long term investment decision.

1. *What is the potential for the development of non-food crops in the United Kingdom? Which crops, if any, are likely to prove significant in terms of economic activity or land use?*

4. In terms of economic impact, crop type ranking is likely to be oils, starches, proteins, fibres, and biomass. Oils could be ranked first as there are existing markets for fatty acids of known value for industry. Some oils containing desirable fatty acids are of extremely high value. At the other end of the spectrum, biomass energy crops are likely to always be of low value as they are simply burned and are competing with low price, convenient mineral oil and gas products. However, any biomass energy crop will by its very nature require large areas of land in contrast with some of the high value oil crops—particularly those for pharmaceutical purposes. The other crop types—starch, proteins and fibres—fall in between these two extremes. Much of the work being conducted in the whole of this sector is commercially sensitive. The potential of some of these different sectors is described below.

Oil Crops

5. The oleochemical industry, using approximately 14 million tonnes of oil/fat each year from both animal and vegetable sources, is based on oils used almost entirely for industrial purposes such as linseed and castor and also on some of the major food oils, especially soya, palm, rape/canola, coconut, palm kernel (and tallow). The exploitation of lipids already available in large quantities for non-food use is being pursued aggressively in the United States for soyabean oil and in Malaysia for palm oil. Similar activity in the United Kingdom would have to be based on rapeseed oil since this is the only oil currently produced at high levels. There are active public sector research centres devoted to oleochemicals in Germany and in Holland but none in the United Kingdom where limited research in this field is confined to the private sector.

6. Traditional soaps are now accompanied by a wide range of other surfactants produced by the oleochemical industry. Indeed, 90 per cent of the output of the oleochemical industry is some form of surfactant. These compounds are used domestically in the bathroom and the kitchen, for industrial cleaning, and in the agricultural, cosmetic, and pharmaceutical industries. Lipids and lipid-based compounds are also used in surface coatings (paints and inks), as lubricants (surface-activity), adhesives, solvents (for cleaning oil-spills), in plastics, and as biodiesel which can be used as an automotive fuel or as a heating fuel.

7. Already there is interest in several new oilseed crops, some of which are being developed for non-food use. Developments are concentrated in United States of America and in Europe (particularly Holland). They include:

Cuphea species (short and medium chain fatty acids)	detergents
Erucic acid-rich rapeseed oil	plastics
Crambe (erucic acid)	plastics
*Coriander (petroselinic acid)	nylons
*Calendula (calendic acid)	see below
Camelina (several acids)	see below
*Lesquerella (hydroxy acid)	alternative to ricinoleic acid
*Dimorphotheca (hydroxy acid)	see below
*Vernonia oils (epoxy acid)	see below

(Those marked with an asterisk contain unusual fatty acids and for most of these new uses will have to be developed. Not all of these will be suitable for cultivation in the United Kingdom.)

8. The example of calendula oil is typical. Attempts are being made to extend the planting of calendula in the Netherlands to about 10,000 ha in year 2000, to raise the oil content from its present level of 18 to 20 per cent to ~25 per cent, and seed yields to around three t/ha which suggests the production of 7,500 tonnes of oil. This oil contains ~55 per cent of the conjugated triene acid calendic (8t10c12c-18:3) and ~20 per cent linoleic acid and can be used in resins and paint formulations leading to reduced VOC emission. There is the possibility of growing this plant in the South of England.

9. *Camelina sativa*, also known as false flax, has a long history and is being rediscovered as an oilseed for agriculture in North West Europe. It is seen as a valuable break crop between consecutive grain harvests and

is remarkable for its low requirement of herbicide, pesticide and fertiliser. The seed contains about 40 per cent of oil and oil yields of 1.2 t/ha are quoted. The oil may be used in animal feeds to enhance the level of linolenic acid, in cosmetics, and has potential food and non-food uses. It has recently been accorded food status in France and the United Kingdom.

Horticulture

10. The horticultural sector has expanded the production of many non-food crops and the United Kingdom is competing with other countries in, for example, the production of cut flowers, herbaceous seedlings, shrubs and trees for the garden trade and local authorities. Some crops, eg narcissus bulb production, have been translated to farm-scale production. Horticultural scale production is probably the best approach to investigating niche markets eg pharmaceuticals, essential oils.

Biomass Energy Crops

11. From existing evidence, short rotation crops (SRC) plus wood chips from conventional forestry can provide feed stocks for small private and public heating and power units. The Government target of 10 per cent of electricity coming from renewable energy sources by 2010 will mean that this form of renewable energy could have a part to play. The problems which will arise when enlarging pilot operations to areas of approximately 2000 ha of land and power stations of more than 10 MWe will concern land ownership, continuity of supply from hundreds of farmers and competition for the feed stock from pulp and board mills. There are, however, a range of crops suitable; for example willow, poplar and miscanthus (Elephant grass). Further work is required in developing these annual crops.

Starches

12. Great steps are being currently made in the knowledge of the structure of different starches to meet industrial needs (eg wheat starch and to a lesser extent potato starch). Further research is needed in biotechnology related to enzymatic changes in the starches of wheat and of potatoes to replace the cost of maize starch to the United Kingdom for industrial uses.

Fibres

13. There is potential in further research into the increasing knowledge of lynase, cellulase and semicellulase enzymes with a view to the use of straw and mature grass in the paper industry. This area of activity could make a contribution to the cost to the United Kingdom of imported wood pulp for paper manufacture. Miscanthus could be another important raw material.

2. *What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg by genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability be overcome?*

Replacement of less renewable resources

14. Many of the crops under development are actually old crops which were superseded by products of the petrochemical industry. By definition their redevelopment can replace less renewable resources. Competing with the petrochemical industry is difficult, however, as the price of petrochemical based products is not a true reflection of their cost to society (pollution costs in terms of health, acid rain, soot, building deterioration etc). This can be taken into account by Life-Cycle Assessment (LCA) coupled with Cost Benefit Analysis (CBA).

15. The annual production of lipids (about 100 million tonnes worldwide) is only 3 per cent of the annual production of oil and of coal. Oleochemicals may have special uses and be environmentally attractive in certain situations but they can have only a trivial effect on total demand for fossil-based fuels and products.

16. Biomass energy crops can be used to provide alternative sources of income to farmers and locally they can provide competitively priced electricity (such as in Northern Ireland). It is estimated that the theoretical energy cropping and forest residue resource in Scotland could contribute around 2.3 GW of electrical generating capacity. However, taking planning, cost and other electrical infrastructural factors into account, the actual resource may only be around 170 MW[1]. More detailed research on the potential for short-rotation coppice alone suggests that whilst there is a theoretical potential for some 500 5MW biomass-to-energy plants

1 Scottish Hydro-Electric plc, Scottish Power plc, The Department of Trade and Industry, The Scottish Office, Scottish Enterprise and Highlands and Islands Enterprise, 1993. An assessment of the potential renewable energy resource in Scotland. ISBN 0-7058-1685-0 98pp. (Available from HIE, Inverness).

if all the suitable land was converted to coppice, a more likely scenario would be around 20–25 5MW biomass-to-energy plants in Scotland, assuming a 5 per cent take up by farmers on suitable land[2]. If one assumes that, for the foreseeable future, patterns of electrical energy consumption in Scotland remain the same (ie peak demand around 5.6 GW) then biomass-to-energy projects will not contribute significantly (<3 per cent). They are therefore likely to be only a minor element in achieving the United Kingdom Government's policy objective of 10 per cent of electrical energy to be generated from renewable resources by 2010 (DTI, 1999) (ranked third behind wind and hydro).

17. Very few soils can support continuous crop removal without added fertiliser, with the amounts of potassium, magnesium and phosphate available for crop growth limited by the rate of soil release by weathering of soil minerals. Certain non-food crop residues could also be used for the replacement of main fertiliser elements.

Enhancement of potential

18. In many cases the economic potential of non-food crops can be enhanced by genetic modification by improving yields, reducing input requirements and providing adjusted quality factors. Most developments in genetically modified oilseeds have been for "agronomic reasons", including herbicide tolerance, male sterility, and insect-, viral-, fungal-, and bacterial-resistance. However, genetic modification is unlikely to transform the economics other than by providing novel quality products. Of greater interest to lipid scientists/technologists is the possibility of producing oils with novel fatty acid and triacylglycerol composition. The best known example is laurate-canola which is a rapeseed plant producing a laurate oil (like coconut and palm kernel oil). Many other modifications are being pursued, mainly in the United States, which are designed to produce oils with improved nutritional properties. These technologies will also need to overcome the type of public reaction to the growing of GM crops that is presently being seen in the United Kingdom. There will, therefore, be a major need for a public communication exercise to convince the population of the benefits and safety of the novel technology.

19. The willow and tree species commonly used for SRC have copious genetic variation and sufficient breeding has been done to suggest that genetic engineering will not be required for some time. The willow clones at Ness Gardens (owned by the University of Liverpool) have numerous clones sufficient to be confident of increasing tonnage per ha and even of increasing wood density (to which calorific value is related).

20. Problems of consistency and reliability can be overcome. Similarly, advances in processing will help the competitive position of novel crops/crop products but it is important to realise that parallel processing developments are taking place in the petrochemical industry.

3. *What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Assessment of non-food crops be carried out, for comparison with conventional materials?*

Environmental and ecological implications

21. The development of non-food crops can have considerable environmental and ecological implications. For the most part these will be positive and are well documented, but it is important to realise that additional crops grown (*vis à vis* set-aside) will tend to increase nitrogen run-off, pesticide use, soil erosion etc.

22. Many of the considerations that apply to the introduction of non-food crops have parallels in the doubts that are currently being expressed in relation to the introduction of GM crops. Therefore, the public debate that could be prompted by concerns about the environmental and ecological impact of non-food crops should not be underestimated. In reality, developments in the agricultural production of crops have always had some impact on the environment and ecology of the United Kingdom. The environment and ecology are not static and both are under constant flux and change. Developments in cropping (or indeed more generally in any aspect of agriculture) should, therefore, be regarded as a question of managing environmental and ecological change. Moreover, it should not be assumed that change is necessarily for the worst. In a number of cases, introduction of non-food crop systems could provide for changes that could be regarded as environmentally and ecologically beneficial.

23. Oil crop lipid-based products have some significant virtues based on their environmental impact: (i) they are easily bio-degraded so that when they are finally discarded they do not remain for long in the environment; (ii) they come from a renewable resource in contrast to material based on fossil supplies, not renewable on a human timescale; (iii) when burnt as biofuel they release carbon dioxide trapped only months before, in contrast to fossil fuels. However, other matters have to be born in mind. Even the growing of a crop has an environmental cost and this is increased by transporting it around the world.

24. Recent research by Peter Read at the School of Applied and International Economics, Massey University, New Zealand, confirms the key role that bio-energy can play in stabilising, and eventually

2 Towers, W., Morrice, J., Birnie, R.V., Dagnall, S. and Aspinall, R.J. 1997. Assessing the potential for Short Rotation Coppice in Scotland. Report to the SOAEFD. MLURI, Aberdeen, 44pp.

reducing, global carbon dioxide emissions. Short rotation coppice can also contribute to bio-diversity of bird life and small mammals, and also has some potential to be designed into the landscape to improve landscape-scale diversity and, more specifically, to be used as buffer strips in reduction of N & P losses to surface waters.

Life-Cycle Assessment

25. Life-Cycle Assessment (LCA) can provide a good indication of the comparison of a specific renewable resource product with its comparable petrochemical derived competitor in terms of global warming, acidification, nutrient enrichment, photo-chemical oxidant creation potential, energy use etc. Linking LCA to Cost Benefit Analysis (CBA) allows these comparisons to be considered on a financial basis. The development of the links between LCA and CBA is a contentious issue but if studies are conducted with sufficient transparency, then these pieces of work can be refined as more information becomes available (see MAFF funded study CSA 2985) and allow comparisons to be made.

26. It would be valuable to carry out a comprehensive LCA on the energy economics, and sustainability, of biomass-to-energy systems in the United Kingdom. These systems depend upon the collection of a low-energy "wet" feedstock from dispersed locations and transportation to a central generating plant. The system therefore requires a high fossil fuel subsidy in terms of transportation requirements. There are also attendant issues such as additional, public, costs incurred in providing rural road infrastructures, the increased use of which would have considerable environmental and amenity impact. The growth of the coppice itself also requires fossil fuel subsidy in terms of fertilisers and support of agricultural operations (planting, harvesting etc.) The exact nature of the nutrient demands of short rotation coppice systems is currently being assessed and this will vary according to species and clonal types. Nonetheless, it is likely that overall the system will show low levels of energy conversion efficiency.

4. *Are there regulatory barriers to the development of non-food crops or disincentives in the current system of taxation and subsidies?*

27. An important result of research at Macaulay Land Use Research Institute has been the recognition that the economics of biomass-to-energy plants are highly sensitive to the costs of transporting the coppice feedsotck (a 5 MW plant requires 26,000 tonnes per annum). A highly attractive strategy for locating biomass to energy plants is therefore to seek sites surrounded by high yielding land and provide incentives for nearby farmers to convert to coppice. Since the economics of biomass to energy plants is highly sensitive to location, it would seem sensible to adopt a more strategic approach to their planning which includes targeted incentives for farmers to grow coppice. Such a strategic approach is not apparent in the current renewable energy policy instruments (Scottish Renewables Order). The initial grants made by the Forestry Commisson and other bodies are useful in establishing SRC but the long-term costs must be revealed by Project ARBRE and similar trials. There should not be financial support which forces up the price of land, and thereby raises the total costs unnecessarily. There could also be more incentives for the use of unused agricultural land (set aside) to promote industrial interest in non-food crops.

5. *In the light of the above, (a) are the current United Kingdom and European Union subsidies for non-food Crops, and the proposals under Agenda 2000, appropriate; (b) are the local, national and European Union regulatory regimes appropriate; and (c) is the level and direction of United Kingdom and European Union public funding for research and development appropriate?*

(a) *Are current subsidies for non-food crops appropriate?*

28. The proposed changes to Agenda 2000 appear to have omitted novel crops on the basis that public money should not be spent supporting yet more crops. However, this means that novel crops are not competing with mainstream crops from a level playing field. In reality, where there is an industrial demand for a fatty acid, it will then make more economic sense to obtain this from a genetically engineered rapeseed *and* claim the area payment rather than develop a novel crop which will not receive an area payment. This issue must be addressed as the proposed rules mitigate against novel crops and the associated bio-diversity they would bring.

(b) *Are the local, national and European Union regulatory regimes appropriate?*

29. None of the present arrangements is sufficient to facilitate and promote the European development of an important level of non-food crop production and use. There is a major need throughout the European Community for rural diversification and there is a significant potential for non-food crops to have an important role in that diversification process. Thus there is a need in both the United Kingdom and the European Union for the development of a policy that is positively discriminating in favour of non-food crops. This should be designed to allow existing non-food crop options to achieve the viability that would allow their commercial development.

30. In terms of regulatory regimes for testing and growing new crops under commercial conditions, it could be argued that the impact of cropping changes on environment and ecology can only really be assessed by a process of monitoring the effects on environment and ecology after a significant change in cropping has been introduced. Otherwise there will always be an argument for doing nothing because of the uncertainty of the impact of change. The alternative, however, of extensive trialing and research prior to commercial growing would provide a more cautious approach to the introduction of change, although a slower one, and it would be the approach favoured by the RSE. Even with extensive trialing, environmental and ecological monitoring is a key activity in the safeguarding of natural resources.

(c) *Is the level and direction of United Kingdom and European Union public funding for research and development appropriate?*

31. In terms of research and development in the United Kingdom, there is need for further work on better conversion and preparation of crop for industrial processes and better co-ordination of objectives and programmes between Government and industry. This should be targeted at achieving the development of a significant European Union non-food crop industry by 2025.

May 1999

Memorandum by the Scottish Crop Research Institute

INTRODUCTION

1. The Scottish Crop Research Institute is a Non-Departmental Public Body (NDPB) with a Governing Body appointed by the Secretary of State for Scotland, which receives grant-in-aid funding from The Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD). SCRI is classified as a Public Sector Research Establishment (PSRE), but it is also a Company limited by guarantee that has Charitable Status.

2. The SCRI Mission Statement is "To sustain excellence and our international reputation for strategic research into crop, plant and related sciences, and to facilitate the application of new knowledge to end-user industries".

3. SCRI is a major international centre for research on agricultural, horticultural and industrial crops, and on the underlying processes common to all plants. It aims to increase knowledge of the basic biological sciences; to improve crop quality and utilisation by the application of conventional and molecular genetic techniques and novel agronomic practices; and to develop environmentally benign methods of protecting crops from depredation by pests, pathogens and weeds. A broad multidisciplinary approach to research is a special strength of the Institute, and the range of skills available from fundamental studies in genetics and physiology, through agronomy and pathology to glasshouse and field trials is unique within the United Kingdom research service.

What is the potential for the development of non-food crops in the United Kingdom? Which crops, if any, are likely to prove significant in terms of economic activity or land use?

4. Activity in the potential for greater use of existing and alternative crops for non-food uses was stimulated a decade ago by the expected availability of surplus agricultural land through the set-aside schemes. While acting as a catalyst for new ideas and outlets, uncertainties due to the variability in the amount of land annually available under the scheme and, latterly, decline in the amount that must be "set-aside" has stifled expansion of crops for non-food uses. Nevertheless, considerable new technologies have become available or are still being optimised. These activities ought to be pursued.

5. Instead of looking at crops *per se*, The Scottish Crop Research Institute has stressed for some time that it is more appropriate to look at the commodities that are required by industry. In partnership, they can then assess the crops that can provide these raw materials either directly or by further processing. The need for a change of emphasis has also been recognised by the current LINK programme entitled "Competitive Industrial Materials from Non-Food Crops" that replaced the previous programme, "Crops for Industrial Use".

6. Your Sub-committee has been made aware of the different commodities that can be produced from plant sources, such as vegetable oils, plant fibres, carbohydrate feedstocks such as starch, biomass for energy production and a wide range of "specialist" products that are produced from plants. Apart from Reed Canary Grass, The Scottish Crop Research Institute has no current research activities that investigate the potential for any crops other than those listed in the POST report, "Alternatives in Agriculture", and POSTnote 125.

7. Land use is irrelevant if no industrial user, whether in the United Kingdom or elsewhere, requires the commodity that a crop will provide, either now or in the future. For example, the United Kingdom currently produces an immense amount of cereal straw that could be used to produce pulp for paper production. However, even though the world-wide demand for pulp for paper is still rising, the demand is being met from trees. It should be noted that all these trees are not being provided from managed and renewable forests. It

should also be noted that the United Kingdom no longer has any chemical pulping facilities that would be suitable, or could be converted to, the pulping of cereal straw.

8. Cereal straw (and all other straws such as oilseed rape stems) is, potentially, a source of energy and is considered as a waste material. Far more use could be made of this resource (see sections 2 and 3 below). As an organisation mainly funded by The Scottish Office Agriculture, Environment and Fisheries Department, The Scottish Crop Research Institute has expressed its concern to the appropriate ministers that a decision was made to omit all biomass projects from the most recent round of the Scottish Renewables Obligation (SRO—3 Renewable Energy). The reason given was that they were not cost-effective. Surely one of the aims of these programmes (NFFO and SRO) was to assess all benefits, economic, socio-economic and environmental.

What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg by genetic modification of plants or plant viruses, or by advances in processing technologies? Can problems of consistency and reliability be overcome?

9. Very few of the commodities listed above will significantly replace the currently used materials under existing economic, socio-economic and environmental considerations. As examples, if the present low price for oil continues, oil-based man-made fibres will continue to be less expensive than plant fibres and, if trees are not produced from managed forests, pulp from specially grown crops will be unable to compete with wood-based pulp for paper production. Unless incentives are provided, less renewable or non-renewable resources will continue to be used and depleted. A long-term approach must be taken or this depletion of resources will continue.

10. Disincentives to use fossil fuel, especially oil, exist in other areas. One of the main debates during the election campaign for the Scottish Parliament was the imposition of petrol and diesel tax rises that were higher than the present inflation levels. These rises in the tax associated with oil prices do not extend to oil, gas and coal for energy use. If the fuel escalator that is being applied to petrol and diesel prices was applied to non-renewable energy sources, the relative economics of biomass energy production would improve. Furthermore, other commodities that rely on non-renewable oil and gas as their raw materials are not being targeted. The artificial fibres, nylon, terylene etc, use oil/gas as raw materials and, if taxed at a higher rate, natural fibres such as flax, hemp and cotton, could compete more readily.

11. Genetic modification does offer many benefits. Until the current debate about genetically modified foods has been resolved, the public will treat all genetically modified plants with suspicion. The Scottish Crop Research Institute recognises that the public does not have grounds for concern, especially about foods. However, a survey conducted by a starch-producing company in The Netherlands indicated that the use of genetically modified plants for non-food (ie industrial) uses was of far less concern to the public. Because a crop is produced for non-food use, no products or co-products will enter the food chain. The only drawback to be resolved is the question of cross-fertilisation.

12. Genetically modified fibre-producing plants have been produced. The amount and composition of lignin (a component of plant fibres) has been altered in transformed tobacco and the technology is been applied to woods. So far, little research has been conducted to enable other fibre-producing plants such as flax and hemp to be transformed. Work is currently underway at The Scottish Crop Research Institute into methods for transforming hemp. This is being funded by a large international foundation.

13. A recent review of starch production in the United Kingdom, involving The Scottish Crop Research Institute, concluded that, under current economic conditions, only wheat starches could compete with imported maize starches to gain a greater proportion of the market. The economics do depend on the value of the co-product, wheat gluten, remaining at its present level. Even though it is a superior product to wheat or maize starches for most uses, the economics of potato starch production are poor.

14. Both conventional breeding and genetic modification will lead to the production of potato starches in which these superior attributes are greatly enhanced. This could alter the economics of potato starch production. However, since there are no facilities in the United Kingdom to isolate potato starch, the United Kingdom does not have a share of the European Union potato starch quota. This may need to be renegotiated (see also section 3 below).

15. POSTnote 125 (page 6) highlights one of the success stories from The Scottish Crop Research Institute. The revolutionary technique to produce novel proteins has been patented. The method uses potato virus X and the desired protein is bound to the virus coat protein. Large proteins (approx 300 amino acids in length) have been attached successfully and, after processing for recovery, yields of 1.0g per kg wet tissue have been achieved. These processing steps are environmentally benign. Exploitation of this technology is at an advance stage. Professor T M A Wilson, formerly of SCRI, has already provided more extensive details of this technology for your inquiry.

What are the environmental and ecological implications of the development of non-food crops? How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?

16. The superior attributes of native potato starches (see section 2 above) can be introduced into maize and wheat starches by chemical processing. Economically, these modified cereal starches can compete directly with native potato starch. However, environmental considerations may need to be reassessed. There is considerable debate about whether some of the chemicals currently being used to modify cereal starches are environmentally acceptable. There is also debate whether the relevant industries are paying the appropriate cost for clean up and processing of the effluent derived from the chemical modification. These considerations could alter the economic costs in the medium to long term.

17. The processing of plant fibres, especially for the production of pulp for paper, has involved environmentally unacceptable chemicals, particularly high concentrations of alkali and chlorine-based compounds. Enlightened countries are making endeavours to eliminate the use of chlorine-based compounds but this is not universal. Research at The Scottish Crop Research Institute has demonstrated the benefits of pulping/bleaching crop residues with more environmentally acceptable chlorine-free agents. Pilot plant studies are needed to progress further but the lack of pulping facilities in the United Kingdom does not encourage optimism about exploitation.

18. Recycled fibre/paper is an unfashionable but valuable commodity. To make material with the qualities required, approximately 20 per cent of the recycled product must be virgin fibre. Incorporation of stronger fibres, such as those from hemp, could reduce the amount required to approximately 1–5 per cent. Indeed, for much of the packaging material that uses recycled "paper", it may not even be necessary to pulp/bleach the hemp fibres with the consequent environmental benefits.

19. There is a demand for lightweight architectural membrane structures. The material used at present is a polyester that is coated with PVC. As the polyesters are synthetic fibres derived from mineral oil and PVC is a chlorine-containing polymer subject to increasingly restrictive legislation in the European Union, replacement materials are being sought. With European Union support, The Scottish Crop Research Institute and the University of Dundee have prepared prototype materials based on natural plant fibres and more environmentally acceptable coatings. Further development is in progress[2].

20. Environmental and ecological implications suggest a greater whole crop use of plants. It has already been indicated (see section 1) that materials such as cereal straw should be part of a whole crop system along with the grain and not be considered as waste. POSTnote 125 (page 2) states that the current yield of short rotation coppice is approximately 7t/ha/year. It should be remembered that average yields of cereal straw are even higher at 9t/ha/year and that does not account for the economic benefit of the grain. The main argument against the use of cereal straw is the need of the cereal farmer to "remove" the straw as quickly as possible after harvesting to allow the planting of the subsequent crop. In this case, the needs are environmental and ecological. A suitable integrated approach to the harvesting of the cereal grain crop and the removal and storage of the straw is required.

21. A subsidiary to the removal of straw is the problems associated with storage of the straw. The crop is harvested over a three to four week period but industry requires its raw materials over the whole year. Physical losses and loss of quality are inevitable but a project under the LINK "Crops for Industrial Use" programme[3] has suggested strategies for reducing these losses.

22. Another whole crop application is the European Union-funded Reed Canary Grass programme. The Scottish Crop Research Institute is one of the partners and the programme has successfully shown that pulp, produced from the stems of this perennial grass, can be used to substitute for up to 70 per cent of the birch pulp in high quality papers, with no loss of quality. The rest of the crop can be pelleted and used as a fuel.

Are there regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?

23. As a Research Institute, The Scottish Crop Research Institute is not directly involved in these matters. We are aware of many of the comments that have and are being made. The committee has taken evidence from other organisations that have a more direct knowledge and understanding of these matters.

In the light of the above, (a) are the current United Kingdom and European Union subsidies for non-food crops, and the proposals under Agenda 2000, appropriate; (b) are the local, national and European Union regulatory regimes appropriate; and (c) is the level and direction of United Kingdom and European Union public funding for research and development appropriate?

24. Crops will not be grown for non-foods uses just because they attract a subsidy. The subsidy may be an incentive to stimulate their use but, ultimately, the products from these crops must stand on their own and compete in the market with other raw materials. Perhaps any subsidy or support should be applied when the "raw material" has been sold for non-food or industrial use.

25. Regulatory regimes are important and Governments may need to take a global view especially of the environmental and ecological effects of products that are produced elsewhere but are sold within their country. As examples:

(a) should a company be allowed to sell paper in the United Kingdom that has not been produced from managed and renewable forests?

(b) should a company be allowed to sell paper in the United Kingdom that has been bleached elsewhere using unacceptably high concentrations of chlorine-based chemicals?

(c) should cars be sold in the United Kingdom that do not contain a high proportion of biodegradable components?

(d) should machinery being used on or close to sensitive watercourses be forced to use biodegradable fuels?

This list could be very large.

26. A number of organisations have been supportive in the non-foods areas. The Scottish Office Agriculture, Environment and Fisheries Department have actively supported both core and flexibly funded research programmes on various aspects of industrial crops at The Scottish Crop Research Institute. Some of the research described above has received significant support from the Department of Trade and Industry through the LINK "Crops for Industrial Use" programme and from the European Union. There are also relevant COST programmes within the European Union.

The Alternative Crops Unit at MAFF has given active encouragement to many areas but should take a more proactive role in the future. ACTIN has been a valuable link with industry and, through its programme of meetings (both formal and confidential) as well as setting up the ACTIN[2020] database, has taken a lead in this area.

The activities of IENICA are somewhat newer and should expand in the future.

References

1 Industrial Markets for United Kingdom-grown Crop Polysaccharides (IMP)—A project funded through the LINK—Crops for Industrial Use programme with support from BBSRC, EPSRC, SOAEFD, Home-grown Cereals Authority and the Potato Marketing Board. Published by the H-GCA as Research Report Number 32 (1996).

2 Development of a New Coated Membrane Textile using Natural Plant-derived Cellulose Fibres. Report to European Union—Contract No BRST—CT97—0682.

3 Storage of Fibrous Crop Materials (FIBSTORE)—A project funded through the LINK—Crops for Industrial Use programme with support from Binnie Environmental, Northern Straw Co Ltd, Stamford Consulting Group, Fisons Horticulture, The Home-grown Cereals Authority, EA Technology, Compak Systems Ltd, Trouw Nutrition and St Regis Paper Co Ltd.

June 1999

Memorandum by Silsoe Research Institute

1. We have seen the recent POST note 125 of March 1999, entitled Non-food Crops, and consider this an excellent summary of the current situation. Below are a few points of emphasis to add, based on our experience of work on the properties, processing and economics of non-food crops. We have for example been involved in the last five years in research on fibres, straw processing, drying and storage of short rotation coppice, and the harvesting of properties of oilseed rape. An SRI leaflet produced three years ago on Crops for Industry, and copies of relevant pages from our latest Biennial Report will be submitted by post with this statement. (*not printed*)

Addressing Question 1: What is the potential for the development of non-food crops in the United Kingdom? Which crops are likely to prove significant . . .

2. The potential of non-food crops in the long term must be very large. The environmental benefits from their renewability will outweigh their current drawbacks in technical and economic performance as the cost of non-renewable materials rises and technical knowledge of how to design to get the best from renewable materials advances. There is potential for research to manipulate the properties of crops to make the processing more efficient and to improve the end product.

3. However most non-food crops do currently need subsidies to be economic; for instance short rotation coppice gets subsidised both at planting via setaside and forestry grants, and at conversion to energy via the NFFO scheme. The question is how much does the Government want to accelerate the necessary improvements in technical properties and processes, for environmental reasons, rather than leave developments to the market forces.

4. If subsidies are to be reduced, the importance of legislation in bringing about change will increase, eg landfill tax, re-use of materials at end of product lifespan. If legislation makes industry seriously consider using plant fibres to replace glass fibre in composites and synthetic fibre in a range of industrial products, the area of fibre crops would be economically significant. If no legislation is developed, fibre crops will probably diminish to a low level, which would represent the loss of a huge opportunity for United Kingdom to move forward in the technologies needed.

5. Non-food products from conventional high yielding crops such as starch from wheat are more likely to be economically successful in the shorter term without large subsidies.

Addressing question 2: What is their potential . . . Can this be enhanced eg by genetic modification of plants or by advances in processing technology? Can problems of consistency and reliability be overcome?

6. Certainly the potential can be enhanced in these ways, and SRI work with biologists at JIC and IACR on developing more shatter-proof oilseed rape to reduce harvesting losses is an example.

7. Consistency and reliability can and must be tackled through research, for example the problems associated with storage. Crops have to be grown and have a season, often a short one, when they are in the correct condition for harvesting. This gives rise to the need to store so as to supply ongoing demand. Storage of crop materials is one area that adds a great deal of cost, particularly if drying is needed, and can reduce quality owing to natural deterioration, spoilage microorganisms and pests.

8. The problems of drying and storage have not been worked through sufficiently. Even if producers know what the needs of the crop are, they are not sure of being able to satisfy these requirements in challenging weather. The result is inconsistent quality between suppliers, from year to year and within batches of material. For woody biomass, the quality requirements are modest and the drying and storage have been quite well developed so the quality of the biomass material appears to be adequate in pilot trials. Systems have not been tested in large scale power generation. For other biomass crop, as the POST report notes for miscanthus, suitable techniques for drying and storage have not yet been developed. Perhaps work has concentrated too much on agronomy and variety development.

9. For crops for other uses, eg fibre crops, the problem of inconsistency is a very important block to their uptake. In some years, the quality of fibre crops is so poor that supplies are unacceptable to the user industries. This can come about because of the need for retting in damp conditions to prepare the fibre for separation. This uncertainty in quality adds to uncertainties in crop supply caused by the effect of subsidy changes on planted areas.

Addressing question 3: What are the environmental and ecological implications . . . How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?

10. We would like to emphasise the importance and value of Life-Cycle Analysis (LCA) in gaining an understanding of the likely benefits to the environment. The POST document recognises this on its fifth (unnumbered) page. The problems are complex, including how to predict what changes will be made (a) in agriculture in response to changes relating to greater use of non-food crops, and (b) in the production of products from non-renewable sources in response to competition from renewable sources.

Examples are:

(a) removing straw to burn it in a power station would mean that P and K fertilisers would need to be added to the soil (possibly by applying power station ash), and also that the organic matter in our arable soils would start decreasing once more, just as in the days of straw burning.

(b) LCA on the use of vegetable rather than mineral oil for chain saws indicates environmental benefits, but the producers of mineral oils would probably soon adjust the properties and content of their product in response to competition, thus reducing the calculated environmental benefits of the vegetable oil.

March 1999

Memorandum by UKELA (the United Kingdom Environmental Law Association)

BIOTECHNOLOGY WORKING PARTY

What is the potential for the development of non-food crops in the United Kingdom? Which crops, if any, are likely to prove significant in terms of economic activity or land use?

What is their potential to replace other less renewable resources, and to pay their way, in the long term? Can this be enhanced, eg by genetic modification of plants and plant viruses, or by advances in processing technologies. Can problems of consistency and reliability be overcome?

Sustainable development has to be the main aim in the protection and maintenance of the environment. This must mean, in the long term, use of renewable resources which have a minimum environmental impact. Within the United Kingdom there seems little doubt that this will include increased growing and use of non-food crops as sources of chemical feed stocks, fuel, raw materials and high value substances such as pharmaceuticals.

Fast growing woody plants is an obvious group which shows promise as a non-food crop, for example willow for biomass for use in renewable energy production. When considering the use of woody plants as energy crops it should be remembered that little has been done using modern conventional plant breeding techniques to improve existing cultivars and develop new ones.

In the case of tree species being grown for biomass almost no assisted genetic improvement has taken place. At best these are only semi-domesticated by comparison with food crops.

When we consider what has been achieved by conventional plant breeding in field crops (such as wheat and maize), and even tree crops such as fruits, the potential for increasing yields (and potentially, therefore, economic impact) is immense. Conventional plant breeding in such plants is, however, significantly affected by the long time-scales involved. (For example, in the case of conifers radiata pine is only in its fourth generation of improvement whilst deciduous trees such as poplar are only in their second). For this reason alone it is likely that use of the techniques of biotechnology and genetic engineering will be essential.

In relation to many other non-food crops, for example for production of specialised feedstocks for bio-degradable plastics or the use of plant viruses for producing novel vaccines, genetic engineering is likely to be the only way that plants containing the characteristics desired can be developed.

What are the environmental and ecological implications of the development of non-food crops. How far can Life-Cycle Analysis of non-food crops be carried out, for comparison with conventional materials?

Life-Cycle Analysis of materials derived from non-food crops is in principle no different from the life cycle analysis of any other product. The potential environmental impacts of non-food crops will need to be considered carefully, but it is essential that this is done in a holistic way to ensure that any detrimental (or perhaps, "only" neutral) effects on wildlife and the countryside are set against environmental benefits from a wider perspective. A parallel could be drawn here with the development of windfarms which give both environmental pluses and minuses at the same time. There are some situations where windfarms would be considered to be too intrusive despite their positive effect in terms of reduced carbon dioxide output and doubtless the same will be true of certain non-food crops.

Are there any regulatory barriers to the development of non-food crops, or disincentives in the current system of taxation and subsidies?

The level of public funding from European Union and United Kingdom sources is arguably not adequate for research and development in this area at its current stage. Much research funding from both European Union and United Kingdom sources requires the academic to have an industrial partner. This means in practice that the major chemical companies must be approached. If academic researchers have to seek industrial partners this bias in favour of research which is in the companies' medium term commerical interest will continue to limit development. Consideration should be given, therefore, to increased state funding for research in this area.

As with the development of new technologies for food crops (recently reviewed by the Environmental Audit Committee of the House of Commons) it is essential that the regulatory system is well thought through. Thorough, yet appropriate, GMO regulation with regard to field trial and commercial release approval will be necessary if non-food crops are to be properly utilised for the benefit of the environment in the United Kingdom.

At the European Union level the set-aside policy may require rethinking to ensure this does not become an economic disincentive to farmers and landowners growing such crops.

United Kingdom Environmental Law Association

31 May 1999

Memorandum by the University of Bath

1. Introduction

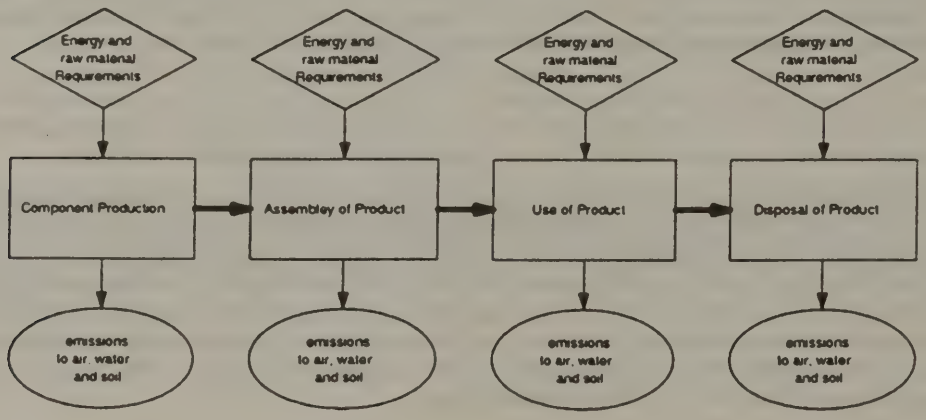
1.1 A research team at the University of Bath has been using Life-Cycle Assessment (LCA) over the last 18 months to compare the environmental impact of alternative fluid power systems. The project is sponsored by the Engineering and Physical Science Research Council (under EPSRC Research Grant GR/L26858) and is being carried out by Marcelle McManus, supervised by Professors Clifford Burrows and Geoffrey Hammond. The research has analysed the use of mineral oils and rapeseed oils employed for fluid power purposes in forestry machinery. The findings of the study enable the research team to respond to the call for evidence regarding the use of LCA to compare the use of non-food crops with conventional materials. Consequently this evidence relates to Question 3 of the Sub-Committee's inquiry only.

1.2 This evidence provides a brief overview of LCA, its usefulness and reliability as an environmental impact assessment technique, and the problems associated with such studies. One of the case studies used in the research at Bath is discussed briefly and its suitability for use as a tool for comparing the ecological impact of non-food and conventional materials is assessed.

2. An Introduction to LCA

2.1 Life-Cycle Assessment is one of a portfolio of environmental management tools (EMT) that have become increasingly popular over recent years. It is a technique that may be used in conjunction with other EMT, such as Environmental Impact Assessment and Environmental Risk Assessment. However, only LCA considers the impacts and effects of a product or system over its entire life cycle. It assesses the energy and materials inputs, as well as the resulting emissions to air and water, and solid waste over the whole product life cycle. This means that the environmental impact of the product or system is assessed from "cradle to grave". Figure 1 shows the life cycle inputs and outputs of a typical production system.

Figure 1: Inputs and Outputs Considered in an LCA Study



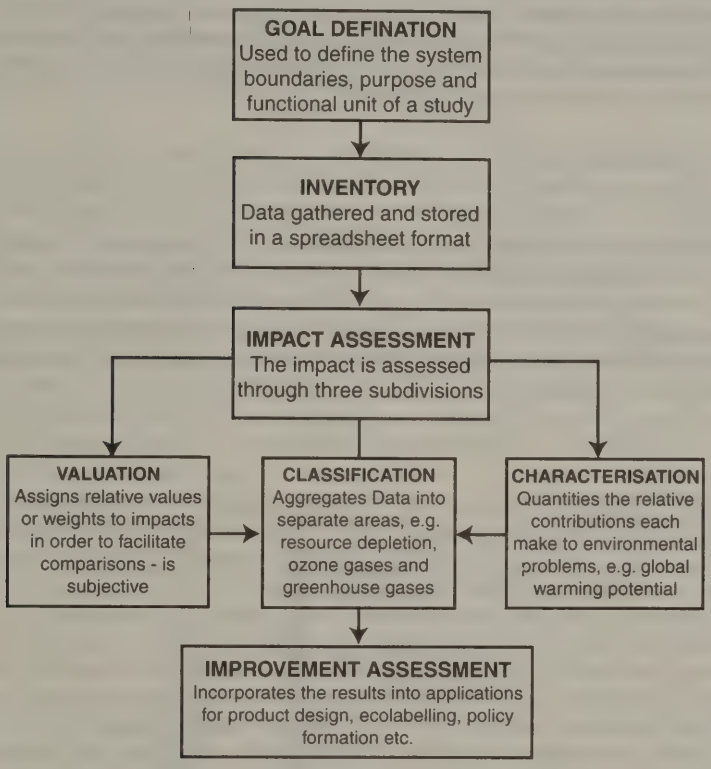
2.2 Until the early 1990's there was no common methodology for LCA. This meant that LCA studies were often incomplete, or their procedures varied so widely that they were not comparable. Then the Society of Environmental Toxicology and Chemistry (SETAC) devised a methodology which has been generally accepted by leading practitioners. The main framework of this methodology has now been incorporated into the ISO 14040 series of international standards on LCA. The SETAC and ISO guidelines provide a framework for LCA. There are four main stages: Goal Definition, Inventory Analysis, Impact Assessment, and Interpretation and Improvement Evaluation They are illustrated schematically in Figure 2. These stages have also been incorporated into a number of the commercial software packages available.

Goal Definition

2.3 This first stage is employed to identify the issues to be examined within a given study. The environmental impact of a whole system or product cannot realistically be presented as a single parameter, and so LCA is employed to assess environmental impacts with respect to various known categories environmental "problems", such as global warming, ozone depletion or acidification. The task of this initial scoping phase is to carefully outline the potential environmental issues involved, and to present clear reasoning behind the choices made. It is important that the process of LCA is transparent in order to avoid the possibility of an unscrupulous practitioner being able to "bend" the results so that one particular product is favoured over another. For example, if a certain outcome was desired by a user, it might be possible to carry out the LCA without examining the contribution to a specific environmental impact category that might

otherwise yield a negative environmental impact. LCA can result in vast amounts of data gathering, and it is at this initial stage that the boundaries of the study are established. If the study is to be a comparative exercise, then the boundaries around the products or systems to be examined must be similar as between the various alternatives.

Figure 2: Stages in LCA as Defined by SETAC (ISO 14040



Inventory Analysis

2.4 This stage involves data gathering as shown Figure 1. It is a very time consuming stage and it can typically take over a year to gather enough data for a thorough LCA. However, the increasing availability of commercial and other databases should reduce this time interval as LCA becomes more commonplace. The information is stored in a database and analysed in the subsequent stage, that of the impact assessment. Care must be taken when using purchased or general access information sources that the data is accurate and specific enough for that particular study. Ideally a verifiable test for validity needs to be applied.

Impact Assessment

2.5 In this stage data is examined with respect to known categories of environmental issues or problems such as acidification, ozone depletion, energy use, global warming, and so on. It has been conducted using a wide variety of different methods. There is still much research to do in devising appropriate assessment methods for particular applications. The stage is typically sub-divided into three elements: classification, characterisation, and valuation. Often there is a fourth element, normalisation, which can either occur before the valuation or often instead of the final valuation stage.

Classification

2.6 The classification stage allows all the data from the inventory to be grouped together into predetermined classes of environmental issues of "problems" as previously outlined in section 2.1. Once the data has been classified there will be several inputs and a variety of emissions resulting from each environmental "problem" considered. The data can therefore be very complex and difficult to comprehend. Consequently a weighting is given to each, and all the contributions to each issue are added together to enable easier comparison.

Characterisation

2.7 The weighing and addition of the inventory data forms the characterisation stage. This allows the different inputs in each class to be amalgamated. The various greenhouse gases (for example Co_2 CFCs and HCFCs) are believed to contribute to global warming with differing degrees of severity. In order to weight these different impacts CO_2 is given a value of 1 and the other greenhouse gases are given a weighting relative to the effect of carbon dioxide. Once the characterisation stage has been completed there will be one "equivalent" emission under each of the classifications. However, this data can still be difficult to interpret. For example, a graph displaying 1000kg of Co_2 equivalent for greenhouse gases, 900 kg of CFC11 equivalent ozone depleting gases, and 800 kg of SO_4 equivalent acidification products would not necessarily imply that the impact to global warming is any greater than that for acidification. None of these different enviornmental issues, or their contributions, can be compared directly.

Valuation

2.8 One potential option to overcome the latter problem is to give a value to each of the categories of emmisson in terms of their importance in a given study. This is a subjective process, and it has not often been carried out in LCA practice. Another possibility is to normalise the data so that it is more easily understood. However this is not a well defined process either, and also has an element of subjectivity. Normalisation cannot be viewed as an alternative to valuation, but it does allow a measure of comparison.

Normalisation

2.9 One method of normalisation, and perhaps the most common, is to compare the data with average European emissions, or with European regulatory limits. This is done in the expectation that such limits are set at a level where each effect will have a broadly comparable impact on the environment. Although this is not strictly the case, it does facilitate easier comparison. However, there are inevitably problems associated with obtaining the necessary data for normalisation. Some countries in the world do not have regulatory limits or emission level data. Date collection and accuracy can also present difficulties. All known methods of normalisation have drawbacks that need to be fully examined in the context of a given study. In the research study at Bath the concept of "people emission equivalents" has been used (see Burrows et al [1]). Data for the average European emissions for each category was obtained. These can have very large numerical values, whereas the emissions for the study were fairly small. Therefore, for ease of comprehension, the total European missions were divided by the corresponding population. This produces an average "people emmission", which were then compared with the emissions in the study to yield "people emission equivalents".

Interpretation and Improvement Evaluation

2.10 In this stage of LCA, graphs may be employed to illustrate the areas of significant impact. These should be examined both as a means of determining ways of improving the process and also as a "double check" on data in the most critical areas. Obviously, the primary aim of the interpretation and improvement stage is to identify areas where significant improvements can be made. These need not be areas with the largest impacts, but may often usefully be those where small improvements can be made most easily. In this final stage, LCA is employed to help improve the environmental performance throughout production, use and disposal of the product or system.

3. Limitation of LCA

3.1 LCA is a very useful approach and set of techniques, but it has many limitations at its present state of development. The methods employed only allow for the examination of global and regional impacts, and not local impacts. This can obviously bias results. However, as long as there are complementary studies carried out which do take into consideration local impacts, then LCA can still be used to good effect. One of the major limitations to LCA is time and data.To undertake a full LCA study requires a vast amount of data, much of which is not within the public domain. Companies are often unwilling to part with the sort of sensitive data required for a full study. The use of more generalised public domain data or estimates obviously decreases the accuracy of the study. Credible databases are becoming available with the rise in popularity of LCA, and these can either be purchased as a commercial database or as part of a software package. There has been a call by the Society of Promotion of Life-Cycle Development (SPOLD) for all LCA databases to be in the same format, thereby making data transfer easier. This to some extent taking place, but the use of LCA is still too limited to enable a practitioner to find all the information needed from a public database. Consequently a lot of time is still invested in gathering input data.

4. LCA Case Study

4.1 The LCA research at Bath has examined case studies related to fluid power systems. In one case the use of conventional mineral oil has been compared with rapeseed oil in the hydraulic systems of forestry machinery (such as logging harvesters and forwarders). This is clearly a very sensitive application from an ecological perspective. A full account of this case study has been reported by Burrows et al ([1] & [2]). The production and use of mineral and rapeseed oil was obviously examined in some detail. However, the disposal process for both oils is currently the same, and so will have no differential impact for the purposes of the LCA study. Data availability and "quality" was a significant problem in this case, although every effort has been made to obtain realistic imputs. Consequently the degree of uncertainty is still quite high. The results will be refined over time as more and better data is obtained. A full sensitivity analysis is currently being carried out. Once this has been completed, areas of potentially high sensitivity will have been identified and can be re-examined.

4.2 The baseline study results shown in Figure 3 show that overall the rapeseed oil has a greater impact on the environment than that of the mineral oil. These results are updated from those originally reported by Burrows et al [2], and take account of better data on the processing of rapeseed oil. The impact of the rapeseed is greater than that of the mineral oil in all categories examined, other than energy use and winter smog. However, if other issues had been examined, such as fossil fuel use and sustainable development, then the overall results may look rather different.

4.3 It is possible, for example, to refine the data used in connection with the rapeseed base oil presented in Figure 3. This could be broken down into separate components and different stages of production and use in order to determine where the greatest effects occur. Such a disaggregation is illustrated in Figure 4. If all the stages in the production and use of the rapeseed are analysed, then it can be shown that the main contributory stages are the crushing of the seeds, the fertiliser production, the drying of the rapeseed, and the natural process of the rapeseed growth itself.

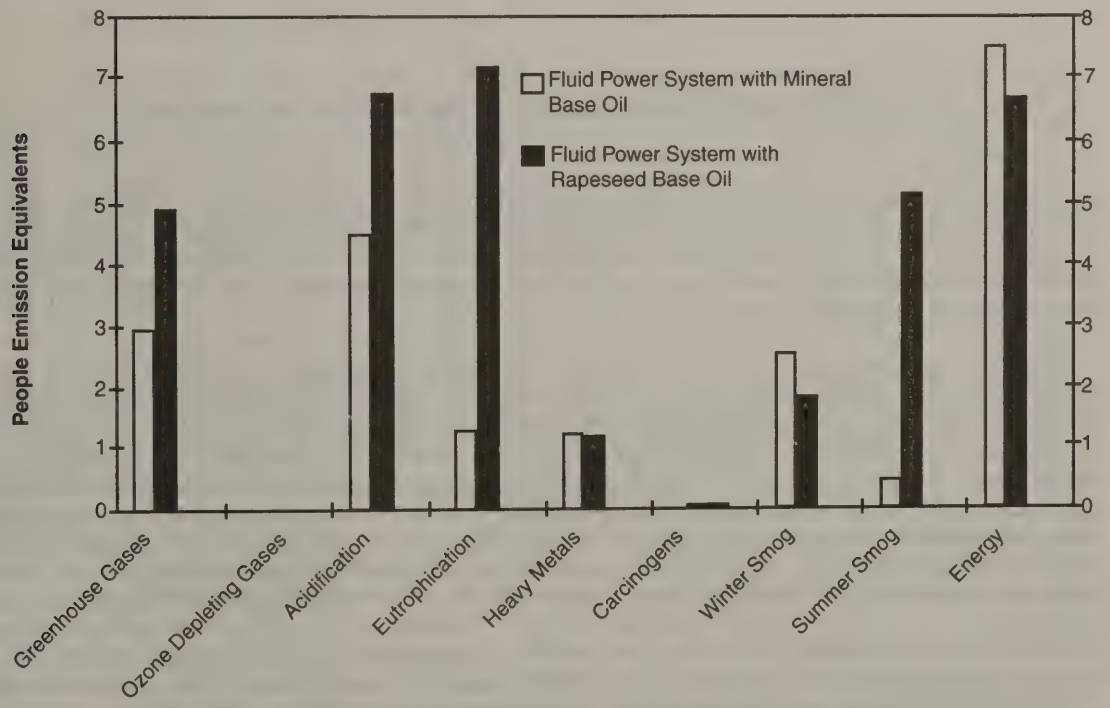


Figure 3. Normalised Comparison of a Fluid Power System over a Fluid Power System over a Fifteen Year Life Cycle using Mineral and Rapeseed Base Oils.

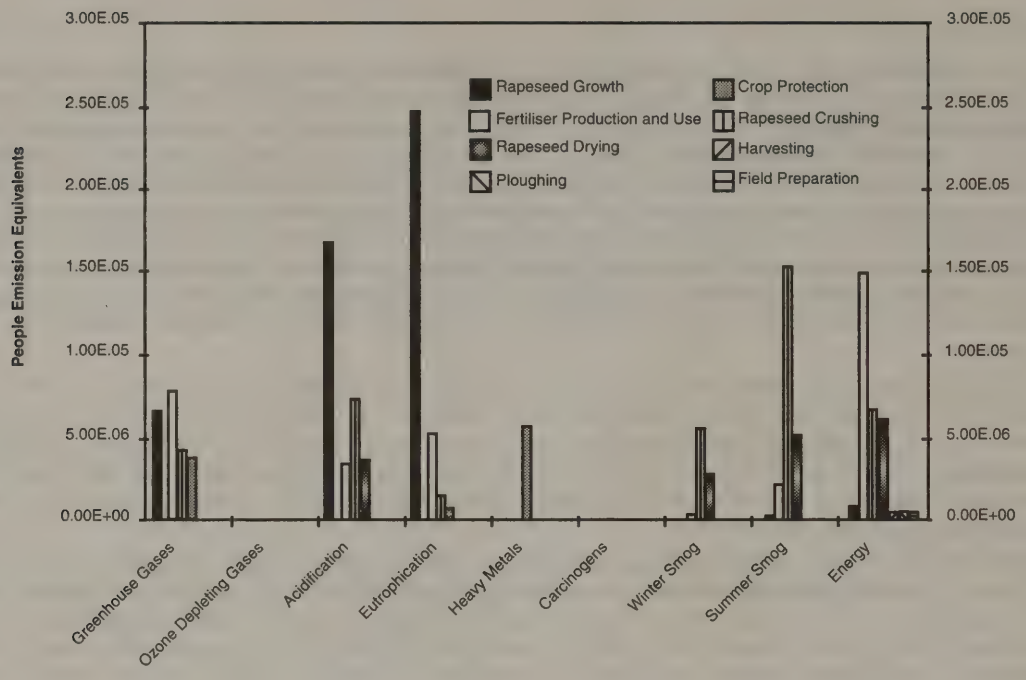


Figure 4. Detailed Normalised Data for the Base Rapeseed Oil Production

4.4 Rapeseed fluids do not have the same properties as mineral fluids, and therefore their hydraulic performance within a fluid power system is very different. At present, with current specifications for hydraulic oil systems, this means that fluids based on rapeseed have to be replaced more frequently than those based on mineral fluids. This will obviously exacerbate the adverse impacts resulting from the production process (and depicted in Figure 4).

4.5 LCA results of this sort enable improvement strategies to be developed for any of the Life-Cycle stages. Those that exhibit large environmental impacts can be further analysed to see if there are any other ways to improve the product or system. Examination of fertiliser production or the rapeseed crushing stage, for example, may indicate whether there are ways to easily improve these processes. However, as the growth of the rapeseed is a natural process it wil be very difficult to improve that element of rapesed production. Once the stages with the larger impacts have been analysed then it is important to look at the stages with smaller impacts as there may be improvements that can be made within these stages which, examined together, could have a significant effect on the overall performance. The way in which LCA can identify such contributions and stages is invaluable, and helps to make it a comprehensive environmental management tool.

4.6 The results of any LCA study may prove to be very uncertain or sensitive to small changes in input data. It is therefore desirable to undertake a sensitivity analysis in order to reduce the uncertainty in the outputs. This involves employing a systematic procedure to evaluate the effect of changes in key variables. If a small change in some item of input data gives rise to a large change in the resultng life cycle impact of the product or system being studied, then the LCA is very sensitive to errors or uncertainties in the estimates for that variable. A sensitivity analysis is currently being carried out at Bath in connection with the study of rapeseed oil in the fluid power systems of forestry machinery. Consequently it would be premature to cite the results shown above as evidence against the use of such non-food crops in industrial processes. Much of the adverse impact attributable to the rapeseed is due to its relatively poor properties as a hydraulic fluid in contrast to conventional mineral oils. This elevates any impacts associated with rapeseed oil that arise from the production phase. This may obviously not be the case with other applications of non-food crops.

4.7 The present LCA study of forestry machinery at Bath has only accounted for global and regional impacts. Local ecological damage caused by oil spills on the forest floor has not been incorporated in the study. This is because it is not possible to handle such effects within the current LCA framework (see paragraph 3.1). Nevertheless, it was surprising to find the overall, global impact of the rapeseed oil was greater than that for the mineral oil. However, these are preliminary results. The sensitivity analysis had not yet been completed, and the reliability of some of the input data is therefore open to question.

5. Critical and Peer Review

5.1 In order to ensure credibility of any LCA study, it is necessary to subject the results to independent, critical peer review. Academic studies, such as those associated with fluid power systems at Bath, area automatically subject to peer review as part of the refereeing process that takes place prior to publication of material in archival scientific and technical journals or conference proceedings. Unfortunately, similar procedures are not necessarily followed in industry, despite this practice being recommended as part of ISO 14042. An example of an attempt to meet this requirement, is the recent LCA study of the environment impacts of PVC products announced by the Minister for the Environment (see DETR Press Release 470, 13 May 1999). This one-year study is being undertaken by a commercial consultancy, following a scoping study by the Building Research Establishment. However, the project outcomes will be "reviewed by life cycle assessment experts throughout the year and the results will be published widely". It is unclear how the DETR will select these "LCA experts', but this sort of practice that should be encouraged. The approach could perhaps be aided by establishing a more formal "College of Peers" along the lines of that used by the EPSRC to review research grant proposals. The Government Departments most closely involved with the use of LCA (principally the DETR and MAFF) should be encouraged to the lead in establishing this type of peer review body, together with interested agencies such as the Environment Agency and the Research Councils (particularly the BBRC, the EPSRC, the ESRC, and the NERC). Professional associations, like the Environmental Auditors Registration Asssociation and the Institution of Chemical Engineers, may also have a role to play.

5.2 There has been much discussion in the industrially-focused literature about the need to divise short-cut or simplified methods of LCA. Given that full LCA studies are still rather in their infancy, and have a number of limitations (see paragraph 3.1), these developments should be discouraged. They are likely to lead to results that may ultimately bring the practice of LCA into dispute.

6. Conclusions and Recommendations

6.1 It has been argued that LCA is a very useful tool for determining global and regional impacts of a product or system from the "cradle to the grave". Currently it is unable to include local impacts, but it is possible that some means to achieve this will be forthcoming in the not too distant future. When employed with other environmental management tools, such as risk assessment, it can form a comprehensive impact assessment package. LCA avoids the examination of products on a "snapshot" basis, whereby only one part of the life-cycle is examined. The latter could yield a misleading impression of the real environmental consequences of adopting non-food crops in place of conventional materials.

6.2 Commercial LCA software or databases are becoming more readily available. They offer facilities that reduce the barriers for the entry of non-specialists. Access to public domain databases will also reduce the time required to perform an individual study, although it will remain significant in the near-term. However, it will still not be a simple task to perform a full LCA, and the expertise and time needed to undertake a rigorous, whole life environmental impact assessment must be recognised. The move towards developing short-cut LCA methods for industrial use should be discouraged. They are likely to produce misleading results and, as a consequence, damage the credibility of carefully prepared assessments.

6.3 The initial stages of LCA, those related to scoping and inventory analysis, can be regarded as well defined and understood. However, the later stages, including the processes of normalisation and valuation are subjective, and many different methods are in current use. This leads to inevitable problems when the results of impact assessments are interpreted. Nevertheless, the use of LCA is still one of the more scientific environmental management tools. Clearly much more research is needed to refine LCA methods and to make them more robust. It is critically important that LCA studies are peer reviewed. This is normally undertaken as part of the refereeing process when the results of studies are submitted for publication in the scientific and technical media. Unfortunately, many industrial studies are not subject to a similar level of rigorous evaluation. There is consequently a need for Government departments and agencies with an interest in the application of LCA techniques over a range of products and systems to establish a "College of Peers" for this purpose. This could have a very real and near-term effect on improving the reliability of LCA studies undertaken in the United Kingdom.

7. References

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27 May 1999

Memorandum by the University of Reading

1. I am a plant biochemist who has been a partner on European Union-funded research projects concerned with melons genetically modified for longer shelf-life (1989–94; 1996–2000), and with chicory as a source of carbohydrate for food and non-food uses (1995–98). I have also led work on an indigo-yielding potential crop (Leverhulme Trust, 1995–99), and I am currently coordinating an application to the European Union Fifth Framework Programme for a project on the development of novel dye-yielding crops.

2. The questions posed by the Committee are best answered by an economist. However as a plant scientist, my view is that the United Kingdom is in a strong position to realise the potential that exists for non-food crops to become valuable contributors to agriculture. Just as engineering manufacturing has been revolutionized by the advent of microprocessors and information technology, agriculture could be revitalized by the technology of genetic engineering. This is a field where the United Kingdom is well placed in terms of expertise in industry, institutes and universities. The United Kingdom is disadvantaged compared with the rest of Europe in commercial interest.

3. It is widely recognized that plants are capable of manufacturing many chemicals for which there is a present, or potential, commercial demand in medicine or industry. If this potential is to be realized on a commercially viable basis we must: (i) raise the consistency of the product (ii) obtain an economic yield (iii) and develop effective extraction techniques. All three areas need research and development. Genetic manipulation can help in all of these areas, even in assisting extractability.

4. Where products can be extracted on the farm, we can avoid transport of bulky plant material, allow recycling of wastes on the farm, and provide rural employment. Indigo from woad for bubble-jet printers provides an example that is already being developed.

Professor Philip John

26 March 1999

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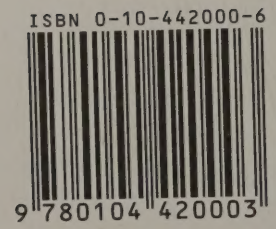

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